From Cubes to Gravitation: Emergent Curvature, Black Holes, and EPR Bridges

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This paper extends the anonymous cube program from mathematical ontogenesis and general dynamical emergence toward gravitation, black holes, and Einstein–Podolsky–Rosen bridges. The primitive world contains oriented labeled cubes, local encounters, ordered updates, recursive wrapping, complete provenance, latent structures, and structured absences. No metric, manifold, force, mass, energy, curvature, horizon, or quantum state is supplied initially. Instead, the system records which local continuations are possible, how many update stages are required for disturbances to propagate, how persistent assemblies alter nearby histories, and how internal clocks compare after traversing different regions. Gravity becomes recognizable when persistent cube organizations systematically deform the propagation and clock relations of surrounding histories. A black-hole-like structure appears when this deformation produces a persistent boundary beyond which every admissible outward continuation is trapped, redirected, concealed in latency, or terminated in structured absence. An EPR-bridge-like structure appears when two separated boundary regions remain joined by a provenance-bearing relational latency that belongs to neither endpoint independently and cannot be reconstructed from either local manifest state alone. The proposal does not claim to derive general relativity or quantum gravity. It defines an auditable generative program through which gravitational concepts may be earned operationally rather than inserted by name.

Keywords: cube physics, emergent gravity, black holes, EPR bridges, structured absence, relational latency, causal horizons, internal clocks, propagation geometry, mathematical ontogenesis, delayed recognition, provenance.

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1. Introduction

The anonymous cube program begins before familiar mathematics. Its primitive cell carries six panel sites, twelve seam sites, eight junction sites, an orientation, and optionally an interior register. Marks occupy these sites without initially being interpreted as numbers, logical values, coordinates, physical properties, or geometric quantities. Cubes may be reoriented, contacted, transformed, separated, assembled, wrapped into higher-order cubes, and supplied with complete replayable histories. Mathematical significance is attached only after stable operational structure has independently emerged. The governing discipline is therefore not merely terminological restraint but provenance restraint: generate first, recognize second, and name last.

The temporal extension converts the primitive cube from a state-bearing object into a history-bearing process. Ordered updates, bounded dependence, limited propagation, persistent patterns, internal clocks, manifest cubes, latent cubes, and missing cubes create the preliminary conditions for a physical world. A manifest cube is directly readable. A latent cube alters future outcomes without possessing an independently readable manifest state. A missing cube is structured nonoccupancy rather than a blank label. These modes provide a substrate in which presence, development, hidden influence, and absence can interact.

The present paper asks whether this substrate can be extended further without abandoning its methodological discipline. In particular, can the system generate behaviors that later deserve to be recognized as gravity, black holes, and EPR bridges?

The easy method would be to place cubes on a predetermined curved lattice, assign numerical masses to selected cubes, prescribe a force varying with distance, designate certain cavities as black holes, and draw tunnels between paired regions. That construction could illustrate established physics, but it would not generate physics. The desired program must proceed in the opposite direction. It must begin with anonymous local updates and determine whether curvature-like propagation, horizon-like boundaries, and bridge-like hidden relations arise as stable descriptions of what the cubes do.

The central proposed chain is:

anonymous local update
→ persistent deformation of nearby continuations
→ altered propagation and clock comparison
→ effective geometry
→ causal trapping
→ horizon-like boundary

→ paired relational latency
→ EPR-bridge-like structure

Each arrow represents a discovery threshold rather than a definition. The later term may be used only when the earlier operational behavior has been generated, tested, and found sufficient.

The proposal is necessarily speculative. The two preceding papers provide ingredients rather than a completed gravitational theory. They supply recursive construction, provenance, locality, limited propagation, internal clocks, latent relations, distributed hidden states, vacancies, cavities, tunnels, and topology-like invariants. They do not themselves derive an Einstein field equation, a Schwarzschild solution, an event horizon, Hawking radiation, or the ER = EPR conjecture. The purpose of the present work is to define the missing generative steps while preserving a clear distinction between source-derived foundations and new conjectural extension.

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2. The Methodological Constraint

Gravity must not enter the genesis ledger as gravity.

The genesis ledger may contain cube identifiers, site marks, contacts, update stages, neighboring addresses, vacancies, latent records, branch choices, wrapping histories, and probe results. It may record that a disturbance required seven updates to cross one region and eleven updates to cross another. It may record that two identical clock assemblies completed different numbers of cycles after following different histories. It may record that a propagating pattern repeatedly changed direction near a persistent assembly. It may record that an outward-moving pattern failed to cross a particular boundary under every tested continuation.

The ledger may not initially state that time slowed, space curved, an object was attracted, a horizon formed, or a black hole existed.

These descriptions belong to the recognition ledger. Their admission requires translations between anonymous cube behavior and the operational content of the familiar physical terms.

This distinction is particularly important for gravity because gravity is easily inserted inadvertently. A rule that tells cubes to move toward dense regions already contains attraction. A rule that reduces propagation speed near a selected assembly already contains something resembling a gravitational potential. A prewarped lattice already contains curvature. A global evaluator that calculates the total cube distribution and updates every location accordingly already contains a nonlocal field equation, even if its output is displayed as local cube motion.

A genuine cube-based emergence of gravity must therefore satisfy a stronger requirement:

No update rule may refer to global distance from a source, total source strength, predetermined curvature, attraction, geodesic motion, or a gravitational field.

Every primitive update must act on bounded accessible context. Large-scale gravitational behavior must arise from repeated composition of those bounded interactions.

The original cube framework already provides a method for handling apparently anomalous local behavior. When the same visible context generates different continuations, the system enlarges the context ladder rather than discarding the outcomes. Additional context may include neighboring cubes, orientation, hidden registers, construction history, latent relations, or surrounding vacancies. This principle becomes indispensable in gravitational ontogenesis. What later appears as a change in geometry may initially appear merely as the failure of a local manifest description to predict propagation.

Suppose two cubes display the same visible marks and receive the same incoming pattern. In an undisturbed region, their next states agree. Near a persistent assembly, however, their next states diverge. Several explanations are possible. The local environment may contain different neighboring marks. The assembly may have modified an interface. A latent state may persist in the surrounding region. A vacancy history may alter the available continuation. The update may depend on a longer historical window.

The system must determine which enlarged context restores prediction. If a bounded enlarged context predicts the altered continuation, the phenomenon remains local at the deeper level even though it appears field-like at the manifest level. If no local manifest description suffices but a distributed latent record does, the apparent field may be a compressed description of relational or distributed history. If prediction requires unrestricted access to the whole world, the candidate model has failed the intended locality test.

Thus the first task is not to make cubes fall. It is to discover whether persistent cube histories can reshape the continuation structure of other histories while all fundamental updates remain bounded.

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3. The Primitive Gravitational World

A candidate gravitational world requires more than a population of cubes occupying a regular array. It requires a distinction between the address structure used for implementation and the effective relations reconstructed by embedded processes.

The address structure is bookkeeping. It identifies which sites may contact, which addresses are occupied, and which local contexts are available to an update rule. It may be regular for computational convenience. It is not automatically physical space.

Effective space must be reconstructed from what propagating patterns and internal clocks can actually do.

Two addresses that are adjacent in the implementation ledger may be operationally distant if many intermediate transformations are required for influence to pass between them. Conversely, two regions that are not manifestly adjacent may become operationally close through a persistent latent relation or a wrapped interface. Distance-like structure should therefore arise from transition accessibility rather than from the visual placement of cubes.

The primitive gravitational world contains at least five operational ingredients.

First, it contains **persistent localized assemblies**. These are not yet masses. They are histories that maintain a recognizable organization across many updates, repair certain disturbances, preserve a boundary, or recur through a stable cycle. The earlier physical framework already treats physical identity as continuity of generative organization rather than unchanged material occupancy.

Second, it contains **propagating probes**. A probe is a reproducible pattern that passes through neighboring addresses while preserving a sufficiently stable operational signature. Different probe families may exist. Some may be localized. Others may be distributed. Some may cycle internally as they propagate and thereby carry their own clocks.

Third, it contains **internal clocks**. A clock is a recurrent assembly whose successive stages provide markers against which other histories can be compared. Clock behavior becomes physically meaningful when clocks can be transported, compared, disturbed, and restored. No external universal time is required. The global update index remains part of the implementation ledger, whereas experienced duration is reconstructed through comparisons among generated cycles.

Fourth, it contains **transition capacity**. At every local context, certain next states are permitted, others are prohibited, and still others branch. The complete pattern of permitted local continuation is more primitive than a trajectory. A trajectory is only one realized history through this changing field of possibilities.

Fifth, it contains **historical modification of transition capacity**. Persistent assemblies may leave altered marks, changed contacts, latent residues, missing-cube patterns, wrapped interfaces, or distributed relational records in their surroundings. The surrounding region then retains

evidence that the assembly exists or has existed there, even when no material cube is transmitted outward from the assembly.

This last condition is the seed of gravity.

A candidate source does not attract distant cubes directly. It locally modifies neighboring transition capacities. Those modified neighbors modify their neighbors during later updates. The alteration propagates outward through finite stages. Once established, it may persist, decay, oscillate, or reorganize whenever the source changes.

The resulting influence is not an additional object placed at every location. It is a reproducible difference in what can happen there.

At the recognition stage, such a distributed condition may be called a field. Before recognition, it is simply a structured regional modification of permitted transitions.

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4. From Update Deformation to Effective Geometry

The fundamental proposal of this paper is that gravity should first emerge as a deformation of histories, not as a force between objects.

Consider a family of standardized propagating probes released through a region containing no persistent source assembly. Their histories establish a reference behavior. The ledger records which local transitions occur, how many clock cycles accompany the propagation, which paths are stable, and how probes respond to small disturbances.

Now place a persistent assembly in the region and repeat the probes without altering their internal construction. If their histories change systematically, the assembly has produced an operational deformation.

The deformation may appear in several forms. A probe may require more local updates to cross one region. A previously stable continuation may become unstable. Several equivalent outgoing branches may become biased toward one family. A transported clock may complete fewer cycles relative to a distant comparison clock. Two probes launched in parallel may converge. A returning probe may fail to retrace the sequence taken by an outgoing probe. A cyclic path may acquire a different total return record depending on whether it encloses the assembly.

None of these observations alone establishes gravity. They become gravitationally significant when they form one coherent, source-dependent, probe-independent structure.

The strongest case occurs when many different probes—constructed from different cube families and carrying different internal marks—reconstruct the same effective deformation.

Their detailed interactions with the substrate may differ, but their large-scale histories agree on which regions are delayed, which paths converge, and which clock comparisons change.

This universality is essential. A deformation affecting only one specialized cube pattern may be an ordinary interaction. A deformation affecting all sufficiently non-disruptive probe families in a common way becomes a candidate geometry.

The transition to geometry therefore occurs when a regional pattern of accessible histories provides a more economical and invariant description than a catalogue of separate forces acting on separate probes.

Effective geometry is not a shape imposed on the cubes. It is a compressed account of common propagation behavior.

The proposal may be stated operationally:

A region earns a geometry-like description when the histories of diverse standardized probes and clocks can be predicted from one shared structure of local continuation.

Gravity then appears when persistent assemblies alter that shared structure.

In this account, matter-like organization and geometry-like organization are not initially two substances. A persistent assembly is itself a history within the cube world. Its continued existence modifies neighboring histories. Those modifications propagate and become part of the conditions under which the assembly and other structures continue. Source and geometry therefore arise from a coupled process.

The intended generative chain is:

persistent organization
→ local transition modification
→ propagated regional modification
→ common probe deflection
→ systematic clock alteration
→ effective geometry
→ gravitational recognition

The theory has not yet produced a law connecting source organization to effective curvature. That law must be discovered from generated worlds. The initial claim is weaker but more fundamental: a curvature-like description becomes possible once persistent structures systematically alter the common continuation relations reconstructed by probes and clocks.

This is the point at which gravity begins to be created from cubes rather than represented by them.

5. Gravitational Sourcehood as Persistent Historical Load

A persistent assembly should not be called massive merely because it contains many cubes. Cube count may eventually correlate with gravitational source strength, but the framework must not assume that relation. A large assembly that is dynamically inert could produce no surrounding deformation, while a smaller assembly with intense internal cycling, repeated wrapping, latent storage, or continuous vacancy production might alter a much larger region.

The more primitive concept is **historical load**.

Historical load is the degree to which an assembly constrains its own continuation and the continuations of nearby structures. It may arise because the assembly preserves many internal relations, requires repeated corrective updates, maintains hidden registers, cycles through latent stages, repairs vacancies, or continually re-establishes its boundary. Its presence consumes or redirects local transition opportunities.

The expression “consumes transition opportunities” does not mean that a numerical resource has already been defined. It means that neighboring contexts have fewer, slower, or differently distributed admissible continuations when the assembly is present than when it is absent.

A source candidate therefore requires a controlled comparison between two worlds. In the reference world, standardized probes propagate through a selected region without the assembly. In the source world, the assembly occupies the region and is allowed to establish its complete surrounding history. The system then compares the resulting continuation records.

A source-like assembly may produce several effects simultaneously. Nearby probes may branch less freely. Propagation may require additional intermediate states. Latent stages may become more frequent. Local clocks may complete different numbers of cycles. Vacancies may move toward or away from the assembly. Interfaces may reorient. Stable paths may converge.

These effects should not be separately programmed. They should arise from the ordinary local rules required to maintain the assembly and transmit changes through neighboring cubes.

This creates a plausible relationship between persistence and gravitational sourcehood. A highly persistent object is not merely one that survives. It is one whose continued survival repeatedly organizes its neighborhood.

The source is therefore not a static collection of cubes. It is a continuing demand imposed by one history upon the surrounding space of histories.

The candidate gravitational source strength might eventually be estimated from the magnitude and range of this demand. One source may alter only its nearest neighbors. Another may generate a modification that propagates outward and remains stable over many wrapping

levels. A third may establish several nested zones with qualitatively different continuation behavior.

No single measure should be chosen prematurely. The genesis program should record several independent operational quantities: the number of altered local contexts, the depth of added update histories, the persistence of the regional modification, the degree of clock divergence, the universality across probe families, and the resistance of the deformation to local disturbance.

If these measures become mutually predictable, they may later be compressed into a common source signature.

At that point, the recognition ledger may compare the signature with mass-energy-like behavior. The familiar term remains justified only if the same source property governs inertial resistance, gravitational deformation, and exchange or conservation processes. The system must not assume in advance that these manifestations are identical.

The cube world may therefore discover that several initially different kinds of historical load become equivalent under sufficiently broad tests. Alternatively, it may discover several gravitational charges rather than one. Either outcome must be retained.

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6. Inertial and Gravitational Behavior

A central test of any emergent gravitational theory is whether inertial behavior and gravitational behavior arise from a common organization rather than from unrelated rules.

An inertial-like property was provisionally described in the preceding physical framework as resistance of a persistent history to changes in its propagation pattern. A strongly self-maintaining assembly may continue its established motion-like sequence despite local disturbances, while a weak pattern may be redirected or destroyed.

Gravitational response, by contrast, appears when the regional continuation structure alters the histories of passing assemblies.

The two phenomena would initially seem different. One concerns a pattern’s resistance to redirection. The other concerns the environment’s tendency to redirect it.

The cube program should not declare their equivalence. It should test for it.

Consider several persistent probe assemblies with different internal constructions. Each may be subjected to a standardized local disturbance in a reference region. The resulting changes

provide inertial signatures. The same assemblies are then released through a source-deformed region. Their resulting path and clock changes provide gravitational-response signatures.

If the ratio between inertial resistance and gravitational response varies among probes, the system has generated composition-dependent falling. The effective geometry would be incomplete or species-specific.

If, however, all sufficiently isolated probes follow the same effective continuation structure regardless of internal composition, then gravitational response has become universal. If the same operational feature that makes an assembly resist ordinary disturbances also determines its response to source-induced deformation, an equivalence-like principle has emerged.

The important result would not be that every cube experiences an equal force. The deeper result would be that free histories cease to require object-specific equations. Once local non-gravitational disturbances are removed, diverse assemblies follow the same regional continuation structure.

The recognition ledger may then describe them as moving freely through an effective geometry.

This provides an anonymous route toward the distinction between forced and unforced histories. A history is forced-like when its local continuation is altered by direct contact, exchange, damage, or a specialized probe-dependent interaction. A history is free-like when it follows the common continuation structure reconstructed from the region itself.

Gravity becomes geometrical when what initially looked like universal forcing can be redescribed as free continuation in a deformed world.

This transition is conceptually crucial. If every probe must contain a rule saying “move toward the source,” the theory contains a force law. If the probes need only obey ordinary local persistence rules while the regional transition structure has changed, gravity has migrated from object-specific dynamics into effective geometry.

The cube system should search for precisely this migration.

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7. Clock Deformation and Gravitational Time

Path deformation alone does not establish gravitation. A stronger theory must alter the relation among internal clocks.

The temporal cube framework defines a clock operationally as a stable recurrent history whose stages can be compared with other processes. It explicitly avoids identifying the global update

count with physical time. Different wrapped levels may update differently, and embedded observers may reconstruct related but nonidentical temporal records.

This allows gravitational time to emerge without manually slowing a universal clock variable.

Place two equivalent clock assemblies in a reference region. Synchronization-like behavior is established when they begin from matched operational stages, remain isolated from disruptive encounters, and later produce corresponding records.

Now move one clock into a source-deformed region while leaving the other in the reference region. After a defined exchange of signals or a later reunion, compare their internal histories.

A gravitational-clock effect exists when the clocks accumulate different cycle records despite having the same construction and undergoing no direct damage. The difference must correlate reproducibly with the surrounding transition deformation.

Several mechanisms could produce such an effect.

The regional modification may insert latent intermediate stages into the clock's cycle. It may delay the propagation of internal repair signals. It may alter the ordering of updates among the clock's components. It may cause some internal branches to repeat before the cycle completes. It may reduce the number of admissible transitions available at each stage. It may modify the clock's wrapping interface while leaving its final visible state intact.

The genesis ledger records only these concrete changes. It does not initially say that the clock ran slowly.

A time-dilation-like interpretation becomes justified when distinct clock designs produce a common comparison law. A specialized clock that alone changes near a source may merely be interacting with the source. Gravitational time requires that many sufficiently stable clock families reconstruct the same ordering of slower and faster regions.

The strongest result would be a common relationship among three observations: propagation paths bend, signal return records change, and internal clocks accumulate different cycles. When these effects are predicted by one effective continuation structure, geometry and time have become inseparable at the recognition level.

The implementation ledger may still update every primitive cube in regular stages. Embedded processes need not have access to that count. Their physical time consists of reconstructible relations among their own histories.

This produces an important separation:

The external update index orders the simulation.

The internal clock relations define the generated world's time.

A successful gravitational cube world must make the second description sufficient for its inhabitants. An embedded observer should not be able to detect a preferred master clock merely by performing local experiments. If the underlying scheduling procedure remains observable, the world has not yet generated a satisfactory relativity-like regime.

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8. Propagation Cones and Causal Order

Limited propagation is already a foundational condition of the cube-based physical world. A local event affects neighboring cubes only through repeated updates, potentially generating a maximum propagation rate.

This bound creates an anonymous ancestor of causal order.

For each event, the ledger can record the set of later events that may be altered by it under permitted local continuations. At an early update stage, only a small neighborhood is reachable. At later stages, the reachable region expands.

No geometric cone need be drawn. The primitive structure is a nested family of reachable event sets.

In an undisturbed region, these sets may have a stable recurrent form. Near a persistent source, however, their shape may change. Outward continuations may require more stages. Some directions may admit more branches than others. Return paths may differ from outgoing paths. Certain addresses may remain inaccessible from particular histories.

When many event families exhibit the same deformation, the reachable sets become part of effective geometry.

The recognition ledger may later call them light-cone-like structures, but the genesis ledger records only finite propagation and accessibility.

This causal structure is more fundamental than visual distance. Two cubes may appear close in the implementation array while requiring many update stages to exchange a signal. Another pair may appear distant yet be connected through a short wrapped interface. Operational causal proximity is therefore determined by reachable histories.

A gravitational source changes causal proximity when it changes these reachability relations.

The first black-hole-like behavior will arise not when a region becomes visually dark, dense, or hollow, but when its causal continuation structure changes qualitatively. A boundary appears beyond which outward influence is no longer possible.

Before defining such a boundary, however, the system must distinguish several weaker forms of trapping.

A probe may fail to escape because it is damaged. This is ordinary absorption.

A probe may remain near an assembly because a repeating local cycle captures its particular construction. This is species-specific trapping.

A probe may enter a cavity and fail to locate an exit because its reading aperture is too narrow. This is observational limitation.

A region may contain no permitted outward contact because the implementation has imposed a wall. This is a fixed boundary.

A black-hole-like region requires something stronger: the trapping must arise dynamically from the same continuation deformation that produces gravitational behavior outside the region.

The horizon is therefore the limiting surface—or more neutrally, the limiting set of contexts—at which outward-accessible histories disappear.

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9. The Anonymous Horizon

The horizon should not initially be defined as a shell of specially marked cubes. It is a property of possible continuations.

Take an event occurring inside a candidate region. Generate all permitted future histories up to increasing depths, preserving every branch and all latent continuations. Ask whether any branch reaches a designated exterior reference domain while retaining a transferable operational signature.

If at least one branch escapes, the event is not absolutely trapped.

If no tested branch escapes, the search depth is increased.

If no branch can escape and a finite structural certificate proves that every permitted continuation remains internal, becomes latent without external manifestation, terminates, or returns inward, the event belongs to a trapped region.

The horizon-like boundary separates contexts that possess at least one outward continuation from contexts that possess none.

This definition is global in its certification but local in its generation. Each transition remains bounded. The trapped character of the region is inferred from the total structure of possible future histories.

That distinction parallels the methodological separation between local rules and large-scale recognized structure. No cube locally carries the label “inside.” The interior is recognized because its continuation graph lacks a path to the exterior.

The horizon may move as the source assembly changes. It may grow when additional historical load is added. It may contract when the source reorganizes or releases latent structure. It may fluctuate if the local rules branch.

A candidate horizon should satisfy several robustness tests.

It should trap multiple probe families, not merely one.

Its existence should persist under small local perturbations.

Its location should be reconstructible by outside observers through signal-return and clock-comparison experiments.

No manifest influence originating strictly inside it should reach the exterior through ordinary permitted propagation.

The horizon should be generated by the same source-dependent transition deformation responsible for exterior curvature-like behavior.

A fixed impermeable cube wall would fail the last condition. It produces confinement but not a gravitational horizon.

The horizon is therefore not fundamentally material. It is a change in the directionality of possible histories.

Outside the horizon, some continuations lead farther outward and some inward.

At the horizon, outward continuation becomes marginal or indefinitely delayed.

Inside the horizon, every admissible future continuation is inward, trapped, latent, or terminating relative to the exterior.

The familiar geometric vocabulary is added only after this operational ordering has been established.

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10. Black Holes as Self-Maintaining Trapped Histories

A black-hole-like object is more than a trapped region. It must combine sourcehood, causal trapping, persistence, and a concealed interior organization.

The candidate structure begins with a persistent assembly whose historical load deforms the surrounding continuation field. As the assembly grows or its internal organization becomes more demanding, the deformation strengthens. Eventually, a closed horizon-like boundary appears.

Once the horizon forms, the interior histories can continue to evolve even though ordinary manifest information no longer propagates outward. The object therefore possesses an externally accessible signature and an internally concealed provenance.

This is precisely the distinction made possible by recursive wrapping. A wrapped cube may expose only selected boundary behavior while preserving a different and much richer internal construction. Two wrapped assemblies may appear identical under all current exterior probes while possessing different interiors and histories.

A black hole can therefore be treated as an extreme dynamical wrapper.

Its external interface exposes only a restricted set of operational responses: deflection of passing probes, altered clock relations, absorption-like encounters, perhaps rotation-like or charge-like signatures, and changes in horizon extent.

Its interior contains continuing cube histories that cannot be directly read from the exterior.

The horizon performs the wrapping, not through an imposed container but through causal inaccessibility.

This suggests an anonymous definition:

A black-hole candidate is a persistent history-bearing assembly whose self-generated continuation deformation creates a closed trapping boundary and whose internal distinctions are inaccessible to ordinary exterior probes except through their effects on the boundary and surrounding histories.

The term “singularity” should not yet be introduced. The cube model does not require infinite density, zero volume, or divergent curvature. Those are features of particular continuum descriptions and may not survive in a finite substrate.

The interior may instead approach one of several regimes.

It may enter a finite recurrent cycle.

It may continue recursive wrapping into deeper levels.

It may accumulate latent transformations that remain hidden from manifest observation.

It may produce expanding structured absence.

It may reach a terminal state from which no further local update is possible.

It may branch indefinitely without repeating.

These alternatives are empirically distinguishable within the genesis ledger, even if all produce similar exterior behavior.

The cube model therefore separates the horizon from the singularity. Horizon formation is a statement about causal accessibility. Interior termination is a separate question.

This separation is valuable because black-hole-like behavior may emerge without any literal infinity. The essential phenomenon is not an infinitely compressed object but a persistent reorganization of possible histories.

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11. Collapse Without Prior Geometry

The formation of a black hole should be generated dynamically.

Begin with a distributed assembly whose local components maintain a stable but nontrapped organization. The assembly may exchange marks, move vacancies, cycle through latent states, and repair defects. Its surrounding influence produces only weak continuation deformation.

Now alter the assembly by adding persistent subassemblies, increasing internal recurrence, constraining its interfaces, or creating new latent dependencies. These changes may increase its historical load.

The source region then requires more local activity to maintain itself. Neighboring continuation structures become increasingly biased. Signals leaving the region require longer records. Internal clocks diverge more strongly from exterior clocks. Outward paths narrow in branch space.

At a critical organizational transition, the last outward continuation disappears.

The horizon has formed.

Nothing in the primitive rule needs to state a threshold. The threshold is discovered as a qualitative transition in reachability.

This resembles other emergent thresholds in the cube program. A cavity appears when missing cubes form a closed interior. A tunnel appears when vacancies connect across an assembly. Connectivity changes when one critical address becomes occupied or missing. The earlier framework explicitly treats cavities, passages, and persistent global vacancy signatures as possible ancestors of topology-like behavior.

Gravitational collapse extends this idea from occupancy topology to history topology.

The critical transition is not merely that a physical hole appears. It is that the space of future continuations becomes divided into causally distinct regions.

The resulting horizon may not coincide with any one layer of cubes. It may pass through contacts, latent interfaces, or wrapped boundaries. Its location is operational and may differ among coarse descriptive levels.

At a fine level, the boundary may fluctuate from update to update.

At a higher wrapped level, those fluctuations may average into a stable horizon signature.

This multiscale character should not be treated as noise. It may be the means through which a discrete substrate supports an apparently smooth gravitational boundary.

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12. Accretion as Transfer of Historical Load

When an external persistent pattern encounters a black-hole candidate, several outcomes are possible. It may be deflected, fragmented, captured temporarily, absorbed into the horizon, converted into latent structure, or annihilated against a vacancy configuration.

Accretion-like behavior occurs when the incoming history becomes incorporated into the trapped assembly and changes its exterior signature.

The incoming object need not remain as a recognizable set of cubes. Its defining marks may be redistributed. Its vacancies may merge with interior defects. Its latent relations may be transferred to the horizon. Its construction history may be wrapped into the black hole's provenance.

The crucial requirement is conservation of whatever invariant signatures the world has generated.

If a probe carries a conserved mark balance, cyclic signature, orientation class, or latent opposition, absorption must either transfer that signature into the black-hole assembly or produce a compensating exterior output. The black hole cannot simply delete a generated invariant without violating the world's established update structure.

Accretion therefore provides an important test of whether the candidate black hole is a genuine physical object rather than a terminal garbage collector.

A successful black-hole world must answer three questions.

What happens to the incoming object's manifest organization?

What happens to its conserved signatures?

What happens to its provenance?

The first may be lost through reorganization.

The second must remain constrained by the generated invariants.

The third remains in the authoritative genesis ledger even when it becomes inaccessible to exterior observers.

This distinction introduces the cube version of the information problem. The global ledger may preserve information that no embedded exterior observer can reconstruct.

Whether information is physically lost depends on which description is treated as authoritative.

The external observer may see many distinct incoming histories collapse into one indistinguishable black-hole signature. At that observational level, distinctions have merged.

The complete cube ledger may nevertheless retain the internal branch history or latent relational record.

The system must not resolve this tension by decree. It should determine whether later events can operationally distinguish the supposedly lost histories. If no possible future encounter can recover the difference, the information has become physically erased within the generated world, even if an external implementation log retains it. If some later process releases a distinguishing signature, the information was concealed rather than destroyed.

Black-hole evaporation, bridge formation, or horizon reorganization may therefore become tests of whether interior provenance remains physically active.

13. Horizon Memory and Exterior State Compression

A black-hole candidate compresses many internal distinctions into a restricted exterior interface. Distinct interior assemblies may produce the same currently observable boundary behavior. The exterior observer therefore replaces a large internal history with a smaller operational signature.

This compression resembles ordinary wrapping in the original cube framework. A wrapped object may conceal its internal assembly while exposing only selected marks and responses. Several different interiors may become indistinguishable under the available external probes, even though their construction trees remain distinct in the genesis ledger.

The black-hole case is stronger because the concealment is maintained dynamically by causal trapping. The interior is not merely covered. Exterior access is prevented by the organization of future continuations.

The horizon may nevertheless retain partial information about what entered. Incoming histories may alter:

the number and organization of horizon cubes;

the distribution of latent interfaces;

persistent orientation-like signatures;

vacancy patterns near the boundary;

the clock behavior of the horizon;

the response of the exterior region to probes;

the threshold for further trapping;

the stability of the black-hole assembly.

The horizon can therefore function as a memory-bearing interface.

It need not display a literal encoding of every interior event. Its state may instead contain a compressed residual signature of the interior provenance. Distinct incoming histories may produce distinct microscopic horizon arrangements while remaining macroscopically indistinguishable.

The system should test this by constructing several black-hole candidates with the same coarse exterior behavior but different accretion histories. Standardized probe families are then applied at progressively finer resolution.

Several outcomes are possible.

All differences may remain permanently hidden.

Some differences may be detectable only through long sequences of exterior interactions.

Some may become visible when the horizon shrinks.

Some may influence a paired latent structure connected to another region.

Some may be erased because the interior update dynamics merge distinct histories irreversibly.

The cube framework must preserve all these alternatives until operational testing distinguishes them.

A horizon-memory principle becomes recognizable if the boundary state carries enough relational information to constrain the future evolution of the hidden interior or any later released output. Such memory could provide the ancestry of entropy-like and information-like descriptions without defining either quantity initially.

The more internal distinctions are compressed into externally indistinguishable states, the greater the apparent loss of accessible information.

The more distinct horizon microstates correspond to the same coarse boundary signature, the larger the hidden multiplicity associated with the black-hole candidate.

A counting structure may later be applied to these alternatives, but the genesis stage records only the family of distinguishable and indistinguishable configurations.

The horizon thus becomes a meeting place of three levels:

the manifest exterior;

the causally concealed interior;

the latent relation between them.

This tripartite structure is essential for the later construction of bridge-like behavior.

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14. Emission From Horizon Reorganization

A black-hole-like structure need not remain permanently closed.

Its horizon may fluctuate because the underlying substrate is discrete, history-bearing, and locally updated. Cubes may become latent, latent structures may become manifest, vacancies may move, contacts may be replaced, and internal assemblies may reorganize. The earlier physical framework explicitly permits transitions among manifest presence, latency, and structured absence.

A horizon fluctuation may occasionally generate an exterior persistent pattern.

Such an event should not immediately be called radiation. It is first recorded as an outward-propagating history produced by a local reorganization near the trapping boundary.

Several classes of emission are possible.

A boundary cube may detach and propagate outward.

A latent horizon structure may become manifest outside the trapped region.

A vacancy pair may reorganize so that one defect remains inside while another propagates outward.

An interior cyclic signature may be transferred to an exterior pattern.

A branch that was previously trapped may become outward-accessible when the horizon contracts.

A paired manifest pattern may arise across the boundary, with one continuation moving outward and the other becoming incorporated into the interior.

The final possibility is especially important. It supplies a cube-native mechanism resembling pair-correlated horizon emission without presupposing quantum fields in curved spacetime.

Suppose a local horizon context contains a latent relational structure capable of producing two correlated manifest descendants. One descendant acquires an outward continuation. The other acquires only inward continuations and becomes part of the trapped assembly.

The exterior observer detects an emitted pattern.

The black-hole assembly changes its internal and boundary signature.

A conserved relational invariant may be divided between the two descendants.

The emitted pattern may therefore carry information correlated with a hidden interior partner.

No particle pair or vacuum fluctuation needs to be assumed at the primitive level. The genesis ledger records one latent relational structure, two manifest continuations, and their divergent accessibility.

An emission-like process becomes physically significant when it is:

reproducible across many horizon contexts;

constrained by generated invariants;

approximately independent of detailed interior construction at coarse resolution;

associated with a systematic decrease in the trapping assembly's historical load;

capable of eventually altering the horizon's extent.

If repeated emission causes the horizon to contract, an evaporation-like process has emerged.

This process may terminate in several ways. The horizon may disappear and release a final manifest assembly. It may leave a stable remnant. It may convert entirely into latent relational

structure. It may terminate in structured absence. It may transfer its hidden provenance through a bridge-like connection.

The cube program should not select among these outcomes based on current physical expectations. Its purpose is to determine which outcomes are supported by the anonymous update rules.

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15. The Need for Relational Latency

An ordinary hidden variable belongs to one cube or one localized assembly. An EPR-like relation requires something different.

The earlier cube physics paper introduces **relational latency**: a latent structure belonging neither to one manifest cube nor to another independently, but to their pair and shared history. Two cubes may separate and return to their previous visible markings while continuing to behave differently because a persistent hidden relation was created during an earlier encounter.

This is the most direct primitive resource for constructing EPR-like behavior.

Let A and B be two manifest assemblies that interact locally. During the encounter, their visible marks may change temporarily, and a relational latent record L[A,B] may be generated. After separation, A and B may return to visible states indistinguishable from states they possessed before the encounter.

Nevertheless, later probes reveal that their responses are correlated.

The predictive context is not the visible state of A alone.

It is not the visible state of B alone.

It is not necessarily a hidden register contained inside either assembly.

It is the joint provenance-bearing relation L[A,B].

The relation has an origin. It was generated through a local encounter or through a connected chain of encounters. It is therefore not arbitrary instantaneous coordination inserted between distant systems.

Once created, the relation may persist even as the assemblies separate through ordinary bounded propagation.

The resulting world contains manifest separation but relational continuity.

This distinction is central:

Manifest locality concerns where readable cubes and their ordinary contacts occur.

Relational latency concerns which histories remain jointly constrained because of their shared origin.

A pair may therefore be spatially separated in the manifest layer while remaining one object at the relational level.

The system should represent L[A,B] as a provenance-complete assembly or record. It may be distributed across intermediate cubes, stored in wrapped histories, encoded through complementary latent states, or maintained by a nonlocal descriptive object whose generation was fully local.

The implementation must avoid turning relational latency into an unrestricted communication channel. If changing A by an arbitrary local action directly changes the manifest state of B during the same update, the model has inserted nonlocal signaling.

A more disciplined construction requires that the relational state constrain joint outcome patterns without allowing either endpoint to control the distant marginal outcome.

In cube language, the probe at A may reveal one branch of the relational structure, and the probe at B may reveal a correlated branch, but neither side independently selects the shared branch in a way that transmits an ordinary message.

The full correlation becomes visible only when records from A and B are later brought together or compared through an allowed causal process.

This is the operational threshold between hidden connection and superluminal influence.

---

16. EPR-Like Pairs From Shared Cube Histories

An EPR-like pair should be generated rather than declared.

Begin with a stable parent assembly P containing a relational latent cycle. Through a local transformation, P produces two manifest descendants, A and B, along with a shared latent record L[A,B].

The descendants separate through ordinary propagation. Each carries a partial interface to the shared relation, but neither carries a complete independent copy of it.

At a later stage, A encounters a probe selected from one of several probe families. B may encounter a related or differently oriented probe.

The outcomes branch.

The system then compares the complete joint record.

An EPR-like structure becomes recognizable when the following conditions are satisfied.

The outcomes at A and B are individually variable or branch-dependent.

Their joint outcomes obey stable constraints.

The constraints depend systematically on the selected probe contexts.

The correlations cannot be reconstructed from the manifest state of A alone or B alone.

The relational latent record predicts the joint structure.

The pair was created through a local provenance-complete history.

No controllable manifest signal passes from one endpoint to the other during the separated measurements.

The exact strength and form of the correlations are not predetermined.

A simple cube model may generate only ordinary shared-history correlations. Such behavior would later be recognized as classical correlation, not quantum entanglement.

To earn a stronger EPR-like interpretation, the system must defeat every attempted explanation based on a predetermined list of local manifest responses carried independently by A and B.

This requires a family of incompatible probes rather than one fixed reading procedure.

A cube may expose different panel, seam, junction, orientation, or wrapped-interface contexts under different probes. A relational latent structure may constrain the possible combinations of responses across these contexts.

The program should enumerate the joint outcomes for each probe pairing and determine whether one common assignment of predetermined local responses can reproduce them all.

If such an assignment exists, the correlation remains classically decomposable.

If no such assignment exists, yet the joint outcomes remain reproducible and no-signaling-like, the cube system has generated a stronger contextual relation.

The recognition ledger may then compare the result with Bell-type or EPR-type behavior.

The familiar theorem must not be inserted into the genesis rules. It may be used later as a recognition test.

The critical generative object remains the shared relational history.

This interpretation changes the ontological emphasis. The pair is not fundamentally two objects plus a mysterious influence. It is one distributed historical object with two manifest endpoints.

---

17. From Relational Latency to Bridge Structure

A relational latent object is not yet a bridge.

A bridge requires an operational form of interior continuity between separated manifest regions.

Suppose A and B are separated endpoints carrying the shared relation L[A,B]. The manifest address structure provides no ordinary short path between them. Signals traveling through the visible cube network require many update stages.

The latent relation, however, may contain an internal sequence of transformation-bearing cells linking the two endpoints within a wrapped or concealed level.

This internal sequence is not an ordinary manifest passage. Cubes cannot necessarily enter at A and emerge at B. It is first a continuity of joint state transformation.

The relation becomes bridge-like when processes at the two endpoints can be represented as boundary manifestations of one concealed assembly.

This may occur through recursive wrapping.

A large assembly containing A, B, their shared origin, and the distributed latent record is wrapped into a higher-order object W. At the higher level, A and B may appear as two exposed interfaces of the same wrapped cell.

From the manifest lower-level view, the endpoints remain distant.

From the wrapped relational view, they are two boundaries of one object.

The original cube framework permits precisely this separation between external behavior and concealed internal construction. Wrapping can expose selected interfaces while retaining a complete hidden assembly and provenance.

A bridge therefore does not require the primitive implementation array to bend or connect visually. It requires two separated interfaces to belong to one internally continuous, provenance-complete structure.

The bridge becomes physically meaningful when this shared interior constrains endpoint behavior in ways that cannot be reduced to independent local states.

Several bridge strengths may be distinguished.

A **record bridge** preserves only a common provenance.

A **constraint bridge** restricts joint endpoint outcomes.

A **transformation bridge** permits changes in the shared latent state to alter the range of possible joint continuations.

A **transport bridge** permits a manifest or latent pattern to pass from one endpoint to the other.

A **traversable bridge** permits controlled manifest transfer in a way observable to embedded agents.

An EPR-like relation requires at least a constraint bridge.

An Einstein–Rosen-like geometric interpretation may require a transformation bridge associated with two horizon-like endpoints.

Traversability is a further property and should not be assumed.

This hierarchy prevents the phrase “wormhole” from being attached too early. A correlated pair may possess hidden relational continuity without permitting anything to travel through it.

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18. Paired Horizons and the Birth of an EPR Bridge

The connection between black holes and EPR relations becomes possible when each endpoint of a relationally latent pair develops a trapping boundary.

Consider a parent assembly P that divides into two persistent descendants A and B while preserving the relational record L[A,B]. The descendants separate. Each accumulates historical load and eventually generates its own horizon-like boundary.

The manifest world now contains two distant black-hole candidates.

Their exterior interfaces are distinct.

Their interiors are causally hidden from ordinary exterior probes.

Their provenance, however, remains joined through L[A,B].

If the shared relation survives horizon formation, the concealed interiors are not independent. They form two exposed boundaries of one larger latent assembly.

At a higher wrapped level, the structure may have the form:

exterior region A
→ horizon interface A
→ concealed relational assembly
→ horizon interface B
→ exterior region B

The arrows do not initially denote spatial travel. They indicate connected construction and transformation provenance.

The recognition ledger may call this an EPR bridge when three independent structures coincide:

the endpoints exhibit EPR-like joint constraints;

each endpoint possesses a horizon-like causal boundary;

the shared latent relation provides a continuous higher-order interior description.

This proposal gives operational meaning to an ER–EPR-like identification without assuming that every entangled pair is literally connected by a smooth classical tunnel.

At weak relational depth, the bridge may be only a constraint structure.

At greater recursive depth, it may acquire a richer interior assembly.

At still greater depth, the effective descriptions of probes and clocks near the endpoints may support a geometry-like interpretation.

The bridge is therefore not an all-or-nothing object. It may emerge through levels.

This suggests a continuum of recognized structures:

shared history
→ relational latency
→ distributed constraint
→ wrapped interior continuity
→ paired horizon interfaces
→ effective bridge geometry

Only the final stages warrant strong geometric language.

The cube system may consequently generate EPR-like connections more readily than classical wormholes. The hidden relation is primitive relative to the effective geometry. What later appears as a geometric bridge may be the coarse description of a deeper provenance relation.

In this sense, entanglement-like structure does not occur inside an already existing spacetime. Effective spacetime connectivity is partly reconstructed from the organization of relational histories.

---

19. Why the Bridge Need Not Be Traversable

A bridge connecting two black-hole interiors may fail to transmit controllable signals.

This is not a defect. It may be required to preserve the generated world's causal structure.

A relational latent bridge can constrain paired outcomes while denying either endpoint unilateral control over the shared state. Local actions modify the endpoint's own manifest continuation, but the distant endpoint's manifest statistics remain unchanged until ordinary records are compared.

The bridge then provides correlation without communication.

A manifest traveler entering one horizon may also fail to emerge from the other. The traveler's history may become incorporated into the shared latent interior without acquiring an outward continuation at the second endpoint.

The bridge is real as a common structure but nontraversable as a transport channel.

This distinction may be implemented through interface asymmetry. Each horizon admits inward continuation from its exterior, but the concealed relational assembly exposes no permitted outward continuation into the opposite exterior.

At the higher wrapped level, the endpoints are connected.

At the manifest causal level, no path crosses from one exterior domain to the other.

The model thereby separates connectivity from accessibility.

A tunnel in ordinary occupancy topology is traversable if vacancies form a continuous passage. A relational bridge need not contain such a manifest vacancy path. Its continuity exists in the transformation and provenance structure rather than in ordinary occupancy.

This is one of the principal reasons latent cubes are necessary. Missing cubes can produce cavities and passages. Latent cubes can produce hidden relational continuity. An EPR bridge requires the latter and may also involve the former, but the two should not be conflated.

A manifest tunnel without relational constraints is merely a passage.

A relational constraint without horizon endpoints is an entangled-like pair.

A paired horizon system with relational continuity but no transport is a nontraversable EPR-bridge candidate.

A paired horizon system that permits controlled transport would be a stronger and potentially causally dangerous construction.

The system should discover whether the local rules permit the last case rather than building it in.

---

20. Bridge Growth and Relational Complexity

The effective size of a bridge should not initially be measured by visual length or spatial volume. It should be measured through the complexity of the concealed relational assembly.

As the two endpoints undergo interactions, accrete new histories, or become more deeply wrapped, the shared relational record may grow.

It may contain more branch distinctions.

It may require more replay steps.

It may preserve more joint invariants.

It may support more internal cycles.

It may contain nested latent structures.

It may acquire additional boundary interfaces.

The bridge may therefore possess an internal developmental history even while its endpoints remain macroscopically stable.

Two endpoint pairs with identical exterior black-hole signatures may possess bridges of very different relational depth.

The system can probe this difference indirectly. More complex bridges may generate longer correlation memories, greater resistance to local disturbance, richer joint response families, or delayed exterior effects after horizon reorganization.

The bridge may also simplify. Distinct latent branches may merge. Correlations may decay. Internal cycles may terminate. Parts of the relation may become manifest as emitted patterns. A horizon may disappear, leaving the relational assembly exposed or redistributed.

The bridge is therefore a dynamical object rather than a fixed conduit.

Its evolution may be summarized anonymously as changes in the minimum provenance-complete structure required to reproduce all joint endpoint behavior.

This minimum structure supplies a natural complexity measure.

No physical interpretation is imposed, but the recognition ledger may later compare bridge complexity with geometric length, interior volume, entanglement complexity, or another known quantity.

Different familiar measures may correspond to different aspects of the same cube history. The framework should preserve this plurality rather than forcing an early identification.

The deeper conjecture is that what mature physics calls an interior geometric region may be a compressed representation of relational computational history.

The cube world would then generate space not merely from adjacency but from the organized depth of possible transformations.

21. Causal Consistency Across the Bridge

The bridge must coexist with limited propagation in the manifest world.

This requirement is not automatically satisfied merely because the latent relation was created locally. A locally generated shared history could still be implemented badly, allowing a later action at one endpoint to overwrite the distant endpoint instantaneously. Such a system would contain hidden nonlocal control rather than an emergent EPR-like relation.

The correct constraint concerns what an endpoint can independently cause.

Suppose the two endpoints are A and B. An observer near A selects one of several possible probes and records an outcome. An observer near B does likewise. The shared latent assembly constrains the set of permitted joint outcomes.

The local outcome at A may depend on the local probe and the unresolved relational branch. The local outcome at B may depend on the local probe and the same relational branch. Yet the distribution of outcomes visible at B alone must not reveal which probe was selected at A before an ordinary propagating record arrives.

The bridge changes joint possibility without creating local remote control.

In anonymous cube language, the condition is expressed through paired ledger comparisons. For each permitted action at A, the system examines the complete family of B-side manifest continuations while withholding the later comparison record. If those local B-side families differ

in a readable manner depending on the distant choice at A, the bridge carries a signal. If they remain indistinguishable under every B-local probe, but joint comparison later reveals structured correlations, the relation is no-signaling-like.

The distinction does not require probability at the primitive level. It can be stated through branch families.

Let one A-side probe produce branches A_1 and A_2. Let a second A-side probe produce branches A_3 and A_4. The corresponding B-side branches may be paired differently in the complete joint ledger. Nevertheless, when the A-side records are concealed, the set of locally available B-side signatures must remain the same.

Stable branch frequencies may later permit a statistical description. The prior cube framework already allows probability-like structure to emerge from persistent relative frequencies among branching outcomes rather than from an initial declaration of randomness.

The bridge may therefore alter correlations without altering locally accessible frequencies.

This supplies an important test of causal consistency. A candidate EPR bridge fails if an embedded agent can encode a chosen message at one endpoint and recover it at the other without a manifest causal chain.

The bridge may still support forms of influence that are invisible locally. The joint latent state may change when either endpoint is probed. Future reunion behavior may depend on both interventions. A later interaction involving both endpoints may reveal the changed relation. None of this constitutes superluminal communication unless one endpoint can extract the distant choice independently.

The model thus distinguishes three levels of effect.

A local manifest effect is readable at one endpoint.

A relational effect changes the joint latent assembly.

A comparative effect becomes readable only after records or endpoints are brought together.

EPR-like behavior occupies the second and third levels while preserving the ordinary causal restrictions of the first.

This is not an optional refinement. Without it, the bridge would undermine the same finite-propagation structure from which effective spacetime emerged.

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22. Observer-Dependent Interiors

An exterior observer and an interior observer need not reconstruct the same world.

The cube framework defines an observer as a generated assembly with a local input interface, an internal cycle, a finite memory, a comparison procedure, and a prediction procedure. Such observers receive only permitted local information. Their descriptions therefore depend on their location, history, clock, and accessible interfaces.

An exterior observer approaching a black-hole candidate detects increasingly altered signal returns, clock comparisons, and propagation paths. The observer may infer a trapping boundary without ever receiving a direct record from beyond it.

An infalling observer, by contrast, may cross the same operational boundary without encountering a specially marked shell. Its local transitions may remain ordinary over a finite interval. The boundary is identified retrospectively because none of its later continuations return to the exterior domain.

This difference is possible because the horizon is not a local material object. It is a global property of future accessibility.

The exterior observer identifies the horizon through failed return and increasing delay.

The infalling observer identifies it only through the later structure of possible continuations.

A third observer associated with the complete genesis ledger has access to both descriptions and to the hidden causal structure relating them. This external ledger observer is not an inhabitant of the generated world and should not be confused with a physical observer inside it.

The distinction among these viewpoints prevents several conceptual errors.

The fact that the implementation records an interior event does not imply that an exterior embedded observer can access it.

The fact that an infalling observer experiences local continuation does not imply that the observer can communicate that continuation outward.

The fact that the complete ledger preserves all histories does not establish that information is physically recoverable within the generated world.

The bridge creates a further observer class. A relational observer may be constructed from both endpoints and their shared latent assembly. Such an observer is not localized at either mouth independently. Its accessible state consists of joint records.

From the viewpoint of a local observer at A, the distant endpoint B is inaccessible except through ordinary signals.

From the viewpoint of the relational observer, A and B are interfaces of one higher-order object.

The two descriptions are not contradictory because they use different reading apertures.

The original cube framework emphasizes that reading resolution determines which distinctions and dependencies are visible. A narrow aperture may exhibit branching that disappears when a larger context is read. Conversely, a coarse reading may collapse historically distinct structures into one apparent state.

An EPR bridge exploits precisely this scale dependence.

At the local aperture, there are two separated objects.

At the joint aperture, there is one relational assembly.

At a still coarser gravitational aperture, there may be two black-hole exteriors connected by an effective interior geometry.

The recognition ledger must preserve all three descriptions and specify the probes under which each is valid.

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23. The Black-Hole Information Problem Recast

The usual question “Is information destroyed?” is too compressed for the cube world.

Several distinct forms of information must first be separated.

There is **implementation information**: everything retained by the external computational record.

There is **genesis information**: every primitive constituent, update, branch, latent conversion, vacancy history, and wrapping operation required for exact replay.

There is **physical interior information**: distinctions that remain capable of altering later events inside the generated world.

There is **exterior-accessible information**: distinctions that an outside observer can recover through permitted probes.

There is **relational information**: distinctions preserved only in a joint structure spanning the black hole, an emitted pattern, or another endpoint.

These categories may diverge.

A history can remain in the implementation log after it has ceased to have any physical consequence. Such information is archived but dynamically dead.

A history can remain physically active inside the horizon while being inaccessible outside.

A history can disappear from both local interior and exterior states while surviving in a relational bridge.

A history can be compressed into a boundary signature that preserves some invariants but discards fine construction details.

The cube program should therefore replace the binary information question with a transition ledger.

For every distinction between two initial histories, the system asks:

Does the distinction remain in the manifest state?

Does it remain in a latent state?

Does it remain in a vacancy or boundary history?

Does it alter any permitted future continuation?

Can an interior observer recover it?

Can an exterior observer recover it?

Can a joint observer recover it?

Can it be reconstructed only from the external genesis ledger?

This procedure yields a classification rather than a slogan.

Two histories are physically merged only when no generated observer, interaction, or later continuation can distinguish them.

Two histories are exteriorly merged when no outside procedure can distinguish them, even though an interior or relational procedure can.

Two histories are latently separated when their manifest projections agree but their future joint behavior differs.

A black hole becomes an information compressor when many incoming manifest histories map to a smaller family of exterior signatures.

It becomes an information concealer when the distinctions persist internally or relationally.

It becomes an information eraser when the distinctions cease to constrain any future generated event.

The framework should not assume that exact reversibility at the implementation level prevents physical erasure. An embedded world may contain irreversible compression even when an external simulator stores all prior states.

Conversely, apparent exterior loss does not demonstrate fundamental destruction if horizon emission, bridge behavior, or final-state reorganization later recovers the distinctions.

The decisive evidence must come from generated probes.

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24. Complementarity as Compatible Partial Ledgers

The cube framework permits a form of complementarity without declaring that contradictory descriptions are simultaneously complete.

An exterior observer may represent an incoming object as becoming encoded in the changing horizon interface. An infalling observer may represent the same object as continuing into the concealed interior. A relational observer may represent the object's distinguishing signature as joining a latent bridge.

These accounts appear to place the same history in several locations.

The apparent duplication disappears when each account is understood as a partial ledger produced by a different reading aperture.

The exterior ledger records every effect accessible through the exterior interface.

The infalling ledger records the local continuation available to the incoming observer.

The relational ledger records the contribution to the shared latent assembly.

None necessarily contains the complete state.

The complete genesis ledger relates them through common provenance.

A consistency condition is therefore required: when the partial records are translated into the common genesis description, they must refer to one developmental history rather than to independently usable copies.

This distinction becomes critical when considering duplication experiments. If one observer could recover a complete exterior copy of an incoming state and later enter the black hole to

compare it with an independent interior copy, the cube world would have generated operational duplication.

The system should test whether such a history is permitted.

Several mechanisms may prevent it.

Exterior recovery may require waiting until the horizon changes so extensively that entry is no longer possible.

The interior pattern may cease to remain independently accessible once its signature becomes encoded at the horizon.

The relational record may be distributed so that neither apparent copy is complete.

The act of extracting a fine exterior signature may alter the horizon and therefore the interior continuation.

The causal structure may prevent the two records from entering one observer's comparison aperture.

These mechanisms should arise from the cube dynamics, not be added as prohibitions.

Complementarity is earned when several observer-relative records are individually valid, jointly noncontradictory in the provenance ledger, and impossible to combine into an operational inconsistency.

It is not the assertion that reality depends arbitrarily on viewpoint. It is the recognition that finite observers access different interfaces of one history-bearing construction.

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25. The Cube Form of ER = EPR

The mature recognition claim can now be stated, but only conditionally.

The cube program does not begin from the identity of Einstein–Rosen bridges and Einstein–Podolsky–Rosen correlations. It seeks an anonymous structure from which both descriptions arise.

Let a generated object R possess the following operational properties.

R is created through a local shared history.

R has two manifestly separated interfaces, A and B.

R cannot be decomposed into independent endpoint states without losing predictive power.

R constrains joint probe outcomes while preserving local no-signaling-like behavior.

R may be recursively wrapped so that A and B become exposed boundaries of one concealed assembly.

Each interface may develop a horizon-like causal structure.

The concealed assembly may admit an effective geometry reconstructed from probe and clock behavior.

Under one probe family, R is recognized as an entangled-like relation.

Under another probe family, R is recognized as a bridge-like interior.

The deepest identity is then not:

bridge = correlation.

It is:

one anonymous relational history supports both bridge-like and EPR-like recognition.

This formulation respects the recognition architecture of the cube program. One generated structure may support several familiar interpretations, and one familiar description may omit distinctions preserved by the original construction. The source paper explicitly allows plural recognition while requiring that every alias remain secondary to the provenance-complete anonymous object.

The cube version of ER = EPR is therefore a multiple-recognition theorem candidate.

Its proof would require explicit translations in both directions.

From the relational description, the system must reconstruct the two endpoints, their joint constraints, and their shared provenance.

From the bridge description, it must reconstruct the concealed connected assembly, the endpoint interfaces, and the causal restrictions on accessibility.

The two translations must preserve all operationally relevant tests.

If the EPR description predicts correlations absent from the bridge description, the recognition is incomplete.

If the bridge description predicts traversability or interior behavior absent from the relational structure, the recognition is too strong.

If both descriptions reproduce the same generated probe library but omit different provenance details, they are complementary aliases rather than exact identities.

Only replay equivalence would justify a stronger claim.

Thus the cube program converts ER = EPR from an asserted physical slogan into a graded recognition problem.

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26. A Minimal Generative Experiment

The full labeled-cube universe is too large for unrestricted exploration. The first gravitational experiment must therefore use a deliberately small substrate while retaining the essential ontology.

The minimal world should contain a finite address region with local contacts, several manifest cube families, at least one latent register class, explicit vacancies, a bounded update rule, and a complete history ledger.

The experiment should not begin by searching directly for gravity or black holes. It should search for anonymous properties in stages.

The first stage searches for persistent localized assemblies.

A seed population of cubes undergoes local encounters. Assemblies that survive, recur, repair damage, or propagate while preserving an operational signature are retained.

The second stage measures environmental modification.

Standardized probe patterns are propagated through the world with and without each persistent assembly. The tracker records path changes, added intermediate states, altered branch availability, clock divergence, vacancy motion, and latent activation.

The third stage searches for universal deformation.

Assemblies are promoted only when several distinct probe families reconstruct a common regional modification. Probe-specific interactions are recorded but not classified as geometry-like.

The fourth stage searches for source scaling.

The program varies the assembly's size, recurrence depth, wrapping depth, latent content, and vacancy structure. It asks which features predict the magnitude and range of environmental deformation.

The fifth stage searches for trapping transitions.

The historical load of selected source assemblies is increased through permitted local construction. Reachability analysis determines whether closed regions appear from which no outward manifest continuation exists.

The sixth stage searches for horizon robustness.

Candidate boundaries are perturbed, rotated, translated, subjected to incoming patterns, and tested under alternative update schedules. A horizon signature must survive changes that do not destroy the source organization.

The seventh stage searches for relational pairs.

Local encounters generate paired descendants with retained latent relations. The descendants are separated and tested under several probe families. Joint constraints, local branch families, and signaling possibilities are recorded.

The eighth stage combines relational pairs with trapped regions.

Each endpoint is permitted to acquire historical load and develop a horizon. The system then determines whether the shared latent relation survives, becomes incorporated into the horizons, or produces a common concealed assembly.

The ninth stage searches for dual recognition.

One analysis track tests the object as a correlated pair. Another tests it as a connected wrapped interior. Neither track may alter the generation rules.

This experimental sequence can be summarized as:

persistence
→ deformation
→ universality
→ source signature
→ trapping
→ horizon
→ relational pair
→ paired horizons
→ bridge recognition

The order matters. Searching directly for a visual wormhole would select by resemblance. Searching for the operational chain preserves the distinction between generation and recognition.

27. The Required Software Architecture

The computational implementation should separate generation, measurement, certification, and recognition.

The **world-state module** stores manifest occupancy, cube marks, orientations, contacts, latent records, vacancies, and wrapping relations.

The **local-update engine** applies only bounded rules. It must not contain named operations corresponding to acceleration, attraction, curvature, horizon formation, entanglement, or bridge construction. The prior physics paper likewise requires the update engine to avoid directly implementing mature physical equations and instead to allow their operational ancestors to emerge.

The **history engine** records every state transition, branch, latent conversion, vacancy movement, object lineage, and wrapping operation.

The **persistence detector** identifies assemblies whose operational signatures survive over selected update windows and perturbation families.

The **probe generator** constructs diverse propagating patterns and internal clocks without optimizing them for expected gravitational behavior.

The **propagation tracker** compares paired worlds differing by one source or event and records the first stage at which each address diverges.

The **clock-comparison module** transports recurrent assemblies through different histories and compares their cycle records after reunion or signal exchange.

The **reachability engine** explores branch-complete future continuations from selected events. It searches for accessibility, trapping, marginal escape, and closed continuation classes.

The **latent-relation engine** distinguishes hidden local state from relational and distributed latency. This distinction is source-supported: the preceding paper allows latent structure to belong to a pair or distributed assembly and explicitly notes that such a description need not require instantaneous nonlocal influence.

The **no-signaling tester** compares endpoint-local branch families under different distant probe choices.

The **wrapper analyzer** determines when separated manifest interfaces belong to one higher-order concealed assembly.

The **invariant detector** searches for preserved mark, boundary, vacancy, cyclic, relational, and lineage signatures.

The **recognition engine** remains downstream. It receives certified operational signatures and compares them with gravitational, black-hole, EPR, and bridge criteria.

The **independent verifier** replays candidate discoveries from the primitive ledger without using recognition aliases.

No discovery should be certified from a rendered image, aggregate statistic, or interpretive label alone.

The exact cube histories must be replayable.

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28. Recognition Thresholds for Gravity

The recognition of gravity should proceed through graded levels.

Level 0: visual deformation. Propagation paths appear curved when drawn. This is suggestive but scientifically weak.

Level 1: probe-specific deflection. One propagating pattern changes near one assembly. This may be an ordinary interaction.

Level 2: multi-probe deformation. Several probe families exhibit related path or delay changes.

Level 3: common continuation structure. One regional description predicts the behavior of diverse probes and clocks.

Level 4: source coupling. Changes in a persistent source assembly reproducibly alter the common continuation structure.

Level 5: equivalence-like universality. Freely propagating assemblies with different internal constructions follow the same effective structure within defined tolerances.

Level 6: observer translation. Embedded observers using internal clocks and local signals reconstruct consistent transformations among their descriptions.

Level 7: independent gravitational regeneration. The complete behavior arises from anonymous bounded cube rules that contain no gravitationally named or mathematically equivalent shortcut.

Only the later levels justify the claim that gravity has emerged.

A model reaching Level 2 may be interesting but should be described as source-dependent propagation deformation.

A model reaching Level 4 may support a field-like recognition.

A model reaching Level 5 may support an effective geometry-like recognition.

A model reaching Level 7 would constitute a genuine ontogenetic result.

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29. Recognition Thresholds for Black Holes

Black-hole recognition requires a separate scale.

Level 0: dark or empty region. A visual cavity exists. This is not a black hole.

Level 1: absorption. Some probes enter and fail to return.

Level 2: broad trapping. Several probe families are captured.

Level 3: continuation closure. Reachability analysis shows that a region lacks outward manifest continuations under the tested rule depth.

Level 4: certified trapping. A finite structural certificate establishes that no permitted outward continuation exists.

Level 5: source-generated horizon. The trapping boundary arises from the same persistent source deformation responsible for exterior gravity-like effects.

Level 6: dynamical horizon. The boundary grows, contracts, or changes in response to accretion and emission while preserving its operational identity.

Level 7: concealed persistent interior. Internal histories continue beyond the horizon while remaining inaccessible to ordinary exterior probes.

Level 8: invariant-constrained accretion and emission. Incoming and outgoing histories obey the world's independently discovered conservation-like signatures.

Level 9: independent black-hole regeneration. No horizon, absorption, or black-hole behavior was inserted into the primitive update rules.

A cavity created by missing cubes may satisfy Level 0 and perhaps Level 1. A fixed one-way interface may satisfy some trapping tests but fail the source-generated requirement.

The term "black hole" should be reserved for the complete conjunction of gravitational sourcehood, robust causal trapping, and persistent concealed interior structure.

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30. Recognition Thresholds for EPR Bridges

EPR-bridge recognition must distinguish ordinary correlation, entanglement-like structure, and effective geometric connectivity.

Level 0: paired resemblance. Two objects look matched.

Level 1: common origin. The endpoints share a recorded parent history.

Level 2: persistent correlation. Their later outcomes remain jointly constrained after separation.

Level 3: relational necessity. Neither endpoint's local manifest and hidden state suffices to reproduce the joint outcomes; a shared relational record is required.

Level 4: contextual correlation. Joint constraints vary systematically with different endpoint probe families.

Level 5: nondecomposability. No tested assignment of predetermined independent local responses reproduces the complete joint probe record.

Level 6: local no-signaling. Distant probe choices do not alter the readable local outcome family before ordinary communication.

Level 7: wrapped continuity. The endpoints are exposed interfaces of one provenance-complete concealed assembly.

Level 8: paired horizons. Both interfaces possess black-hole-like causal boundaries.

Level 9: dual structural translation. The same anonymous object supports both an EPR-like joint-state description and an interior bridge-like description.

Level 10: replay equivalence. Every operationally relevant feature of each description translates into the other without adding unsupported behavior.

A common history alone does not produce an EPR bridge.

A nondecomposable correlation alone does not produce a geometric bridge.

A tunnel alone does not produce entanglement.

The strongest recognition requires all three structures—joint constraint, hidden continuity, and horizon geometry—to converge upon one anonymous provenance-complete object.

31. False Positives and Degenerate Constructions

A system built to discover emergent physics will inevitably produce structures that resemble gravity, horizons, or bridges without possessing the required operational depth. These false positives must be classified in advance because visual and narrative resemblance are unusually persuasive in a cubic world.

The first false positive is **decorative curvature**. A rendered array may be bent into a bowl around a dense cluster, making the result look gravitational. Nothing has emerged unless probe histories, clock comparisons, and continuation relations reconstruct that deformation independently of the rendering.

The second is **programmed attraction**. A local rule may inspect a gradient, count nearby source cubes, or choose the continuation that decreases distance to a designated object. Even when implemented through nearest-neighbor updates, such a rule already contains the meaning of attraction. It may be a useful discrete gravitational model, but it does not satisfy the stronger ontogenetic requirement.

The third is **substrate drag**. Dense cube regions may simply slow every update because the implementation performs more calculations there. This creates apparent clock dilation but reflects computational workload rather than generated physics. The world-state update schedule must therefore be separated from the operational histories experienced by embedded clocks.

The fourth is **probe-specific scattering**. One pattern may curve because its labels interact asymmetrically with a source assembly. That is an ordinary force-like interaction. Geometry-like behavior requires broad agreement among independently constructed probe families.

The fifth is **fixed absorption**. A rule may delete any cube entering a selected region. The region then appears black-hole-like but possesses no source-generated deformation, dynamical horizon, or concealed continuing interior.

The sixth is **ordinary enclosure**. A shell of cubes may prevent escape through physical obstruction. This creates a prison or cavity, not a causal horizon. Removing one wall cube would open the region, whereas a gravitational horizon should be defined by the global organization of possible continuations rather than by a literal wall.

The seventh is **hidden teleportation**. A latent relation may copy a manifest state from one endpoint to another. This creates a nonlocal communication device, not an EPR-like relation. Correlation must be distinguished from controllable remote state transfer.

The eighth is **precomputed correlation**. Two descendants may carry matching lookup tables established at their common origin. Their later outcomes can be strongly correlated while

remaining fully decomposable into local predetermined responses. Such behavior is shared history but not yet nonclassical relational structure.

The ninth is **manifest tunneling**. A line of vacant addresses may join two regions and permit ordinary passage. The earlier cube physics framework already allows missing cubes to generate cavities and tunnels. Such topology-like structure may become physically important, but it should not be confused with a latent EPR bridge unless joint relational constraints and paired horizon behavior are also present.

The tenth is **external omniscience**. A global controller may examine the entire world and coordinate remote outcomes while presenting the changes as local cube events. The visible steps may look distributed, but the causation remains external and nonlocal.

The eleventh is **recognition leakage**. Once a candidate structure looks like a known physical object, the designer may alter the rules to improve the resemblance. The cube framework explicitly prohibits using later recognition to justify earlier generation. Known physics may define an external test suite, but it must not silently rewrite the anonymous genesis process.

The final false positive is **selective reporting**. An enormous search may contain rare histories resembling almost any desired phenomenon. A valid discovery must include the unsuccessful cases, the selection rule, the search budget, the frequency of the candidate behavior, and the exact criteria applied before the result was seen.

A credible cube-based gravitation program must therefore preserve negative records as carefully as successful ones.

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32. Falsification Conditions

The project should state what would count against its central conjectures.

The weakest conjecture is that anonymous history-bearing cubes can generate effective geometry-like behavior. This conjecture would be weakened if every persistent source candidate produced only probe-specific interactions, with no common deformation reconstructed across independent probes and clocks.

It would be weakened further if apparent universality always depended on designer-selected probe families while newly generated probes exposed incompatible continuation structures.

The gravitational conjecture would fail in a particular world if source deformation could not be separated from substrate update artifacts, fixed address geometry, or hidden global computation.

The black-hole conjecture would fail if every trapped region reduced to one of three simpler mechanisms: deletion, material enclosure, or specialized capture of selected probe types.

It would also fail if no source-generated deformation ever underwent a qualitative reachability transition from partial escape to complete trapping.

An apparent horizon would be rejected if sufficiently deep branch exploration repeatedly found rare outward continuations. Failure to observe escape at finite depth is not a proof of trapping.

The EPR-like conjecture would fail if every separated correlation could be reconstructed from independent endpoint records established at their common origin.

It would fail more strongly if the only nondecomposable correlations required direct instantaneous modification of one endpoint by the other.

The bridge conjecture would fail if relational latency never produced a coherent concealed assembly with two endpoint interfaces. Correlation alone would remain correlation.

The ER–EPR-like conjecture would fail if the EPR-like and bridge-like descriptions consistently attached to different anonymous structures rather than to one structure under different probes.

A still deeper failure would occur if the requirements of local no-signaling, strong contextual correlation, horizon formation, and wrapped interior continuity proved mutually incompatible under every bounded rule explored.

Such a negative result would remain scientifically valuable. It would show that the primitive ontology is insufficient or that additional modes of structure are required.

The cube program must therefore allow several outcomes:

gravity emerges but black holes do not;

black-hole-like trapping emerges without EPR structure;

EPR-like relations emerge without geometric bridges;

bridges emerge but remain ordinary hidden tunnels;

all three emerge but cannot be unified;

none emerges under the permitted rule family.

The purpose of the search is not to guarantee the desired physics. It is to determine which physical structures the substrate can actually earn.

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33. Search-Space Discipline

The complete cube population and complete encounter-rule space are too large for direct enumeration. The original mathematical paper treats this not merely as a computational inconvenience but as a reason to search for compact local generators, recurrent transformations, compression principles, and reusable structures.

The gravitational extension should adopt the same strategy.

The search should begin with very small mark families and short local history windows. A primitive cube need not use all possible panel, seam, and junction labels at once. The full architecture may be retained while initial experiments restrict the active distinctions.

The first rule families should vary only a few operational features:

whether matching interface marks persist or change;

whether mismatched contacts create latent records;

whether local cycles repair or amplify vacancies;

whether wrapped assemblies modify neighboring interfaces;

whether relational records survive separation;

whether transition opportunities are preserved, transferred, or temporarily concealed.

The rules should be generated from neutral syntactic templates rather than written individually to imitate known physics.

A template may inspect:

the current cube;

one contacted neighbor;

one nearby vacancy;

one latent interface record;

a bounded history segment;

one orientation relation.

The template may then choose among anonymous actions:

preserve;

replace;

exchange;

rotate;

manifest;

conceal;

vacate;

occupy;

wrap;

detach;

branch.

The search engine should enumerate or sample complete parameterizations of these templates.

The resulting worlds are screened first for basic viability. Worlds in which every pattern freezes, explodes indiscriminately, disappears, or becomes globally synchronized may be recorded and discarded from deeper analysis.

The remaining worlds are screened for persistent localized histories.

Only after persistence is found should environmental deformation be measured.

This ordering avoids spending gravitational analysis on worlds that contain no stable candidates for sources, probes, or clocks.

Compression should guide promotion. A world is especially interesting when one compact local rule produces many scales of organization: persistent assemblies, propagating patterns, source-like deformation, trapping transitions, and relational pairs.

Such a world demonstrates generative unity.

A separate rule for each physical phenomenon would provide simulation but not ontogenesis.

The best candidate rules should therefore be judged by **cross-domain fertility**. A single rule family is favored when the same primitive mechanisms participate in object persistence, field-like modification, clock behavior, horizon formation, and relational latency.

No requirement of elegance should override evidence. Yet a short rule producing several independent physical structures is epistemically stronger than a patchwork designed after each target is known.

34. Seed Selection Without Physical Naming

The seed-selection problem is delicate.

If the search retains only worlds displaying attractive motion, curved paths, black regions, or paired correlations, known physics has already entered through the fitness function.

A neutral fertility criterion is needed.

Candidate worlds may be selected for:

persistent but nonstatic structures;

bounded propagation;

multiple stable scales;

repair after disturbance;

diverse interaction outcomes;

recurrent internal clocks;

regional modification of transition behavior;

creation of new reusable rules;

latent records that remain operationally relevant;

vacancy patterns with persistent global effects;

branching that becomes predictable through enlarged context;

observer assemblies capable of retaining records;

compression of many histories into short generators.

None of these criteria names gravity or quantum mechanics.

A world satisfying them is merely dynamically fertile.

Gravitational, black-hole, and EPR tests are applied afterward by an independent recognition process.

This separation should extend to human inspection. Ideally, seed worlds receive anonymous identifiers. The recognition team or module evaluates the operational records without knowing which rule templates produced them.

Candidate rules should also be tested under nearby perturbations. If a phenomenon appears only at one isolated parameter choice and disappears under every slight rule variation, it may be a fragile accident. If related structures occur throughout a connected rule region, the phenomenon has a developmental neighborhood.

The distribution of outcomes across the rule family matters as much as the best example.

Several possibilities may arise.

Gravity-like behavior may be common once persistent sources and bounded propagation exist.

Horizon formation may require a narrower transition regime.

EPR-like relational structures may arise only when latent records survive separation.

The conjunction of paired horizons and nondecomposable correlations may be extremely rare.

Alternatively, all of these behaviors may cluster around one simple transition principle.

The clustering itself would become a discovery. It could reveal which primitive mechanisms jointly support geometry, causality, and relationality.

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35. Candidate Primitive Mechanisms

Although the search must remain neutral, several anonymous mechanisms deserve investigation because they follow directly from the preceding cube ontology.

The first is **interface burden**.

A persistent wrapped assembly may require its neighboring cubes to maintain special interface states. Those neighbors then expose altered interfaces to their own neighbors. The effect propagates outward as a regional modification.

No attraction is specified. The source merely imposes a recursively transmitted compatibility burden.

The second is **transition borrowing**.

An assembly may preserve itself by drawing upon locally available replacement opportunities. Neighboring histories consequently require additional stages or alternate branches. A region surrounding a highly persistent assembly becomes slower or less permissive without any explicit slowing parameter.

The third is **latent mediation**.

Manifest transitions may require temporary latent cubes. A source assembly may increase the frequency or depth of latent mediation in nearby histories. Probes then accumulate additional hidden stages while their visible step structure remains superficially similar.

The fourth is **vacancy polarization**.

Persistent assemblies may separate vacancy-like and extra-occupancy-like defects. Moving vacancies could reorganize around the source and change the local accessibility of manifest continuations. The resulting defect environment may redirect propagating patterns.

The fifth is **history-dependent contact**.

The response of an interface may depend not only on current marks but on how often or in what order it has interacted with a persistent assembly. The surrounding region then stores a distributed memory of the source.

The sixth is **recursive wrapping load**.

An assembly containing many nested levels may require several internal stages before presenting one external update. Neighboring assemblies coupled to its interface may inherit this deeper update rhythm. Wrapped depth could thereby become a source of clock deformation.

The seventh is **branch funneling**.

A source may not move probes directly. Instead, it may eliminate some outward branches while retaining inward or tangential ones. Repeated local branch reduction creates apparent attraction and eventually trapping.

The eighth is **relational conservation**.

When a parent assembly divides, some invariant may remain representable only as a relation between the descendants. No independent state assignment to either child preserves the complete invariant. This mechanism is a natural candidate for EPR-like pair formation.

The ninth is **dual-interface wrapping**.

A relational assembly may expose two distant manifest interfaces while its internal construction remains concealed. The endpoints then behave as separate objects under narrow probes and as one object under joint probes.

The tenth is **horizon conversion**.

As branch funneling strengthens, a dual-interface assembly may develop one-way causal boundaries at both exposed interfaces. The relational interior remains connected while ordinary exterior transport remains impossible.

These mechanisms are not claims that gravity or entanglement has already been derived. They are neutral generative motifs whose consequences can be tested.

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36. The Emergence of Smoothness

A finite cube substrate appears discontinuous. Familiar gravitation is usually described through smooth geometry. The theory must explain how an effective smooth description could become useful without assuming that the substrate itself is continuous.

Smoothness should be treated as a relation between descriptive scales.

At the primitive level, each event is discrete. A cube changes, a contact forms, a latent state activates, or a vacancy moves.

At an intermediate level, recurrent groups of events are promoted into stable behaviors. A propagating pattern may advance one wrapped address after many primitive updates. A clock tick may contain an entire internal cycle.

At a higher level, many wrapped cells form a regional structure. Fine fluctuations become invisible to observers whose probes interact only with the exposed interfaces of those wrapped cells.

A smooth path emerges when a long discrete history can be compressed into a stable continuation rule whose prediction error decreases under coarser observation.

A smooth clock rate emerges when many cycles produce a stable comparative ratio.

A smooth horizon emerges when microscopic fluctuations in the trapping boundary remain bounded and average into a persistent coarse interface.

A smooth bridge interior emerges when an extensive latent relational assembly can be represented by a smaller family of continuous-like parameters without losing the tested endpoint behavior.

The system should measure smoothness operationally.

A coarse description is successful when it predicts probe histories across larger regions using fewer records than the primitive ledger while preserving the outcomes of the relevant tests.

Different observers may reconstruct different degrees of smoothness because their reading apertures and clock resolutions differ.

A very fine observer may detect cube-scale anisotropy.

A coarse observer may reconstruct rotational or directional invariance.

The emergence of isotropy is therefore as important as the emergence of continuity. A regular cubic implementation privileges certain directions. Effective geometry becomes physically convincing only if the observable behavior of large-scale probes ceases to depend strongly on those privileged directions.

This may occur through:

large assemblies using many orientations;

random or quasiregular local orientation changes;

recursive wrapping that averages directional distinctions;

multiple microscopic paths producing the same coarse history;

dynamic rearrangement of contacts;

probe widths much larger than the primitive cube scale.

The cube need not disappear ontologically. It must become difficult to detect operationally at the scales where the gravitational description applies.

Residual anisotropies would constitute predictions or defects of the model, not details to be hidden.

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37. Effective Dimensionality

The primitive cell is cube-like, but the physical dimension of the generated world should not be assumed merely from its visual form.

Implementation addresses may be arranged in three apparent directions. Yet operational dimension depends on how many independent continuation directions are available to generated probes and how those directions scale with distance-like reachability.

A world may be implemented as a three-dimensional cube array while behaving effectively as a lower-dimensional network because most contacts are inactive.

A recursively wrapped world may display more effective dimensions because latent interfaces supply independent continuation channels unavailable in the manifest array.

Dimensionality should therefore be recognized from probe behavior.

The system can examine how the number of reachable, mutually distinguishable contexts grows as the permitted propagation depth increases.

It can examine how boundaries scale relative to enclosed operational regions.

It can determine how many independent local displacement procedures are required to reconstruct nearby addresses.

It can test whether paths can pass around one another without forced contact.

It can compare the return behavior of loops and the persistence of cavities or linked vacancy structures.

These observations may later support recognition of a dimensional geometry.

The bridge introduces an important complication. Manifest and latent layers may possess different effective dimensionalities.

The manifest exterior may behave three-dimensionally.

The latent relational assembly may possess a more highly connected continuation structure.

A black-hole horizon may act as an interface between these descriptions.

What appears to the exterior observer as a compact boundary may encode a much larger internal relational structure.

This possibility does not need to be expressed immediately through higher-dimensional geometry. The genesis ledger simply records that the minimum internal construction required to reproduce the boundary behavior grows more rapidly than the visible interface.

A mature recognition theory may interpret this as an interior dimension, an emergent volume, or a holographic-like relation. The cube program should first establish the operational scaling.

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38. Boundary–Interior Relations

The black-hole candidate creates an extreme relation between boundary behavior and concealed interior organization.

The original cube architecture already permits several different internal assemblies to expose identical external interfaces. The black-hole extension adds a dynamic reason why the interior cannot be directly inspected.

This raises a central question:

How much of the concealed interior can be reconstructed from the horizon?

Several regimes are possible.

In the first regime, the boundary records almost nothing. Many radically different interiors produce identical present and future exterior behavior.

In the second regime, the boundary stores a compressed invariant signature. Interior distinctions sharing the same invariants remain externally indistinguishable.

In the third regime, long sequences of sufficiently fine boundary probes reconstruct progressively more of the interior.

In the fourth regime, the entire physically active interior can be reconstructed from the complete horizon history, even though it cannot be read at one instant.

In the fifth regime, reconstruction requires both horizon endpoints of an EPR bridge. Neither boundary alone is sufficient.

The last possibility is especially significant. Information that appears missing from one black hole may survive only in the relational state joining two horizons.

The relevant object would then be neither interior alone nor either boundary alone. It would be the complete boundary–bridge system.

A holographic-like recognition becomes possible if the operational content of the concealed interior can be reconstructed from a lower-order boundary history.

But the cube program must distinguish several claims often compressed under the word “holography.”

The boundary may merely correlate with the interior.

The boundary may encode only conserved signatures.

The boundary may predict future exterior behavior without reconstructing interior detail.

The complete boundary history may reconstruct the physically active interior.

Two paired boundaries may jointly reconstruct one relational interior.

These are different discovery levels.

The most demanding claim requires an explicit reversible translation between the interior genesis record and the boundary record under a defined class of physical distinctions.

Until that translation exists, the model has boundary compression, not full holographic equivalence.

The cube system may discover that some interior details are provenance-only. They remain in the external construction ledger but never affect any future generated event. Such distinctions need not be represented at the boundary because they are no longer physically active.

The correct reconstruction target is therefore not the entire implementation history. It is the complete set of distinctions that remain operationally consequential within the generated world.

39. Horizon Multiplicity and Entropy-Like Structure

A black-hole candidate may possess many microscopically distinct horizon arrangements that produce the same coarse exterior behavior.

One horizon may contain different panel marks, latent interfaces, vacancy histories, internal orientations, or wrapping trees while responding identically to the current exterior probe library. These configurations should not be declared identical. They are indistinguishable only under a specified observational aperture.

The number and organization of such alternatives provide the operational ancestry of an entropy-like quantity.

The primitive ledger does not assign a logarithm, temperature, or thermodynamic meaning. It records:

the distinct horizon configurations;

the exterior tests under which they agree;

the transformations connecting them;

the interior histories compatible with each configuration;

the extent to which future probes distinguish them;

the frequency with which the dynamics visits them.

An entropy-like description becomes appropriate when coarse exterior states correspond reproducibly to families of finer horizon and interior states.

This multiplicity may grow when the black-hole candidate absorbs additional persistent histories. Incoming objects can alter microscopic boundary arrangements while leaving the

same broad gravitational signature. The horizon then acquires more possible realizations compatible with its coarse state.

The relevant multiplicity need not count all imaginable cube configurations. It should count only configurations reachable through the world's permitted update histories and indistinguishable under the selected exterior probes.

Reachability is essential. A formally possible horizon configuration that can never be produced from the active rule set contributes nothing to the generated physics.

The cube world may reveal several candidate multiplicities.

One may count distinct present horizon states.

Another may count distinct complete horizon histories.

A third may count concealed interiors compatible with the same boundary record.

A fourth may count relational bridge states compatible with two endpoint interfaces.

These measures need not agree.

The system should determine which one best predicts future behavior. If the probability-like frequency of horizon transitions, emission patterns, or equilibrium-like states depends primarily on one multiplicity, that measure gains physical significance.

An entropy-like quantity should therefore be earned through predictive compression, not selected because it resembles a familiar formula.

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40. Why Boundary Size May Matter

A mature gravitational theory associates black-hole entropy with horizon area rather than ordinary enclosed volume. The cube program must not import that relationship, but it can ask whether an analogous scaling emerges.

A horizon is the interface across which exterior accessibility changes. Any interaction between the concealed interior and the exterior must therefore be mediated by horizon contexts, latent boundary relations, or changes in the surrounding continuation structure.

If the number of independently modifiable boundary contexts limits the number of exteriorly distinguishable black-hole states, then the coarse information capacity may scale with the horizon interface rather than with the number of interior cubes.

This possibility follows naturally from the architecture.

The exterior observer cannot directly address interior cubes.

The observer can act only through accessible boundary interfaces and surrounding fields of altered continuation.

Interior differences that never influence these interfaces remain exteriorly indistinguishable.

Increasing interior complexity without increasing boundary-distinguishable behavior may therefore add provenance without adding exterior information capacity.

The system should test this rather than assume it.

Construct several trapped assemblies with different concealed interior sizes but comparable horizon interfaces. Determine how many exteriorly distinguishable operational states each supports.

Then construct assemblies with similar interiors but different horizon interface complexity.

Several outcomes are possible.

Exterior distinguishability may scale mainly with interior size.

It may scale mainly with boundary size.

It may depend on both.

It may depend on the bridge structure connecting the boundary to the interior.

It may saturate because the probe library has insufficient resolution.

A boundary-scaling law becomes significant only if it persists across several source families, wrapping depths, and probe resolutions.

The cube model may also clarify what “area” means in a discrete emergent world. It need not be the number of visually exposed cube panels. It may instead be:

the number of causally active boundary contexts;

the number of independently addressable horizon interfaces;

the number of distinguishable transition channels between exterior and concealed histories;

the minimum boundary record required to predict exterior behavior.

The geometric interpretation comes later.

The genesis quantity is boundary capacity.

If boundary capacity predicts hidden-state multiplicity, emission behavior, and horizon response, the recognition ledger may compare it with area-like entropy.

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41. Temperature-Like Behavior From Horizon Emission

Temperature should not be assigned to a black-hole candidate merely because it emits patterns.

A temperature-like description requires a stable relation among emission frequencies, emitted pattern classes, source state, and the response of standardized detectors.

Suppose the fluctuating horizon produces several outward-propagating pattern families. An exterior detector records their operational signatures and arrival histories.

The first question is whether the emission is idiosyncratic. If every output reflects detailed interior marks, the process may be ordinary leakage.

A stronger phenomenon occurs when many different black-hole interiors with the same coarse horizon signature produce approximately the same coarse emission distribution.

The emission then depends more on the horizon state than on the detailed concealed construction.

The second question is whether standardized detector assemblies approach a recurrent distribution of internal states when exposed to the emission. If detectors with different initial conditions converge toward the same family of response frequencies, the radiation-like environment has an equilibrium-forming capacity.

The third question is whether two black-hole candidates can be compared through exchange. If coupled through a manifest region, does one tend to transfer persistent patterns to the other in a direction determined by their horizon states?

Only after such behaviors emerge should a temperature-like ordering be introduced.

A hotter-like black hole would be one whose emitted histories drive standardized detectors and other black holes toward a characteristic higher excitation or transition activity.

No numerical temperature scale is required initially. The system may first discover only an ordering.

Candidate A may consistently transfer activity to candidate B under symmetric coupling.

Candidate B may transfer activity to candidate C.

If these comparisons are stable and transitive, a scalar-like description may later compress them.

The cube system should also determine whether horizon size, historical load, and emission activity are related.

A familiar expectation would be that stronger or larger black-hole candidates emit differently from weaker or smaller ones. But the direction and functional form of this relation must remain open.

The purpose is not to reproduce a known temperature law by parameter fitting. It is to determine whether local horizon reorganization generates a robust thermodynamic-like structure at all.

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42. A First Law Without Imported Energy

The cube world may eventually generate a relation among black-hole growth, horizon change, accretion, emission, rotation-like structure, and conserved signatures.

It should not begin by naming this relation a first law.

The primitive ledger records changes between two stable black-hole states. For each transition it records:

the incoming persistent histories;

the outgoing histories;

changes in horizon capacity;

changes in internal recurrence;

changes in latent bridge structure;

changes in orientation-sensitive behavior;

changes in conserved mark or vacancy signatures.

The system then searches for combinations that remain balanced across many transitions.

Suppose every accepted input increases the horizon's operational capacity by a predictable amount unless part of the input is emitted or transferred into a bridge. Suppose rotation-sensitive input alters a separate boundary cycle. Suppose another conserved signature changes a distinct family of exterior responses.

A compact balance relation may emerge connecting these changes.

The relation would not initially contain energy, temperature, entropy, angular momentum, or charge. It would connect anonymous measured signatures.

Recognition becomes justified only after the terms have independently earned those physical interpretations.

This ordering prevents circularity. The balance law does not prove that a quantity is energy-like merely because it occupies the position traditionally assigned to energy. Each candidate quantity must already possess conservation, transfer, and dynamical significance.

The strongest result would be a single transition law predicting which stable black-hole states can follow from which accretion and emission histories.

Such a law would demonstrate that black holes are not merely traps. They are structured thermodynamic-like objects embedded in the world's invariant economy.

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43. Rotation-Like Black Holes

A black-hole candidate may preserve orientation-dependent internal cycles.

The original cube substrate contains explicit orientation, reorientation, seam alignment, junction coincidence, and transformation cycles. These structures provide ample resources for generating rotation-like behavior without inserting continuous angular coordinates.

Consider a persistent source assembly whose internal history circulates through a recurring sequence of oriented contacts. Its surrounding transition deformation may become direction-dependent.

Probes traveling with the recurrent interface sequence may experience different continuation opportunities from probes traveling against it.

Internal clocks transported around the source in opposite senses may accumulate different records.

The horizon itself may support a moving cycle of marks, vacancies, or latent states.

These observations provide the operational ancestry of rotation.

A rotating black-hole recognition requires more than an asymmetric shape. The source must possess a persistent directed cycle that:

survives reorientation of the complete implementation;

alters nearby propagation in a reproducible handed manner;

can be transferred or changed through encounters;

contributes to an independently conserved signature;

affects the horizon and bridge structure.

A source with a static irregular boundary may deflect probes asymmetrically, but this does not establish rotation.

The relevant distinction is between fixed anisotropy and transported cyclic orientation.

A rotation-like black hole may also generate a region outside the horizon in which no stable history can remain completely aligned with the distant reference background. Every persistent local assembly may be forced into some degree of co-cycling because the available continuation structure itself rotates.

The genesis ledger would record the absence of stationary continuation classes and the systematic directional transport of probes.

The recognition ledger may later compare this with frame-dragging-like behavior.

Again, the mature name is not permitted to determine the construction.

The phenomenon is first:

source-supported circulation of continuation structure.

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44. Charge-Like Black Holes

A second independent exterior signature may arise from generated opposition and conservation.

The cube physics paper proposes that extra occupancy and structured vacancy may become operational opposites when they cancel through restoration of a recurrent template. It also proposes manifest and latent opposition through cyclic transformations.

These structures may supply charge-like behavior.

Suppose a persistent assembly carries an imbalance that cannot be removed through internal cancellation. The imbalance modifies surrounding transition contexts in a manner distinct from historical load.

Two assemblies carrying the same imbalance class may alter one another differently from assemblies carrying opposite classes.

Opposed assemblies may restore a neutral template when combined.

The imbalance may transfer between objects while a total residual signature remains invariant.

If a black-hole candidate absorbs such an imbalance, its exterior response may change even though the original carrier becomes inaccessible.

The horizon then exposes a charge-like signature.

The system should distinguish this from source strength.

Historical load may produce universal continuation deformation.

The imbalance signature may produce composition-dependent interactions with selected probe classes.

A mature description may therefore contain both gravitational and charge-like effects, but they must emerge from different operational structures.

The black-hole candidate may be characterized externally by a small set of coarse signatures:

historical load;

orientation-cycle signature;

opposition or imbalance signature;

horizon capacity;

relational bridge state.

Many internal histories may collapse into the same external signature family.

This would provide an anonymous route toward a no-hair-like recognition: complicated interiors become externally describable through only a few conserved or persistent parameters.

The cube system should not assume that the list is short. It should discover how many independent exterior signatures remain after the probe library becomes sufficiently rich.

A true no-hair-like result would be the unexpected compression of a vast interior possibility space into a small operational boundary classification.

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45. The Exterior Signature Problem

To determine whether black holes possess a small family of externally measurable properties, the system must refine its exterior probe library.

Probes should test:

deflection and delay;

clock comparison;

directional asymmetry;

response to opposite imbalance classes;

absorption thresholds;

horizon fluctuations;

emission families;

joint behavior with another black hole;

bridge-dependent correlations.

Two black-hole candidates belong to the same current exterior class when no available exterior experiment distinguishes them.

This statement remains provisional. A later probe may separate the class.

The system should search for a minimal distinguishing probe family. If only a few measurements are required to predict all other tested exterior behavior, those measurements form a compact black-hole signature.

Several different interiors may share that signature.

The system must then determine whether their future exterior behavior remains identical under all permitted accretion histories or only under the current test set.

Stable exterior classification is stronger than present indistinguishability.

A candidate classification becomes law-like when the signature, together with incoming histories, predicts every later exterior state without needing concealed interior details.

This would mean that the interior has become dynamically screened from the exterior except through the coarse signature.

Such screening is not guaranteed.

The horizon may carry long-term memory, producing different emissions or responses for black holes with the same present coarse state but different histories.

In that case, history remains an external parameter even when present appearance agrees.

The cube ontology is especially suited to detecting this because provenance is never discarded automatically.

A black hole may therefore possess hair in its history even when its instantaneous boundary appears simple.

The recognition ledger should distinguish:

instantaneous exterior simplicity;

finite-history exterior simplicity;

complete future-response simplicity.

Only the final form supports a strong no-hair-like claim.

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46. Interaction Between Black-Hole Candidates

Two black-hole candidates may approach through the ordinary propagation of their source-deformed regions.

Their interaction should not be programmed as mutual attraction. Each source modifies neighboring continuation structures. As the modified regions overlap, the possible histories of both assemblies change.

Several outcomes may emerge.

Their exterior paths may converge.

Their horizons may deform.

A common trapping boundary may form around both.

Their internal relational structures may merge.

One candidate may absorb the other.

They may enter a stable recurring orbit-like history.

They may exchange persistent emitted patterns.

They may separate after a complex encounter.

The system should compare the combined evolution with the histories each would have followed in isolation.

A merger-like event occurs when two independently persistent trapped assemblies become one trapped assembly with a shared horizon and a unified exterior signature.

The post-merger object must preserve or redistribute the world's invariant signatures. Historical load, orientation cycles, opposition classes, and relational records cannot disappear arbitrarily.

The merger may also emit propagating disturbances into the surrounding continuation structure.

Such disturbances would not initially be called gravitational waves. They are regional changes generated because the source deformation has changed rapidly.

A wave-like recognition becomes appropriate when the disturbance:

propagates outward with a stable limiting rate;

alters probe paths and clock relations as it passes;

preserves a recognizable oscillatory or polarized signature;

weakens with operational distance;

can be generated by several different source reorganizations;

acts universally on sufficiently passive probes.

The source is not sending a material stream of cubes. It is changing the regional continuation structure, and that change propagates.

This is the cube ancestry of gravitational radiation.

A black-hole merger would therefore provide a demanding integrated test. It must combine persistent sources, effective geometry, moving horizons, invariant transfer, emission, and observer reconstruction within one bounded local update system.

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47. Gravitational-Wave-Like Histories

A static source produces a persistent regional deformation. A changing source produces a changing deformation.

Because propagation is finite, distant regions cannot update their continuation structure instantly. The change travels outward as a sequence of local modifications.

The resulting history may become wave-like if it contains recurrent alternating distortions rather than a single monotonic front.

A cyclically changing source may produce an outward sequence in which one family of transverse continuation relations strengthens while another weakens, followed by reversal.

Standardized probe assemblies encountered by this disturbance may experience temporary changes in their mutual operational separation.

Internal clocks may remain locally stable while the paths connecting them oscillate.

After the disturbance passes, the local region may return approximately to its earlier state, perhaps retaining a residual memory.

The genesis ledger can test these properties without imposing a continuous wave equation.

It records:

the source transition;

the first affected neighboring contexts;

the propagation order of the disturbance;

the alteration of probe histories;

the restoration or nonrestoration of the background;

the invariant signatures carried by the disturbance.

A gravitational-wave-like recognition requires universality. Different probe constructions should reconstruct one common moving deformation.

The disturbance should not behave like a specialized particle interacting only with selected labels.

Polarization-like classes may arise from the cube's orientation structure. Distinct recurrent arrangements of seam, panel, and junction modifications may alter probe separations in characteristically different patterns.

The cubic substrate may initially privilege several discrete polarization classes. Recursive wrapping and coarse averaging may reduce them to a smaller effective family.

Residual additional classes would constitute a genuine prediction of the generated world.

The system should not eliminate them merely because known theories use a narrower classification.

48. Horizon Formation as a Phase Transition

The transition from strong source deformation to a closed trapped region may resemble a phase change in the space of histories.

Before the transition, every interior event retains at least one outward continuation.

Near the transition, outward branches may become rare, long, or unstable.

At the transition, the last outward class disappears.

After the transition, all future manifest continuations remain internal relative to the exterior domain.

This qualitative change can be studied through order-like parameters without naming them physically.

One candidate parameter is the fraction of tested branches that escape.

Another is the minimum history depth required for escape.

Another is the number of distinct outward continuation classes.

Another is the stability of escape under local perturbation.

Another is the boundary capacity of the trapped set.

The system should track these quantities as the source organization changes gradually through allowed updates.

Several transition types are possible.

Escape classes may vanish abruptly.

They may narrow continuously toward zero.

They may fluctuate in and out of existence.

Different probe families may lose escape at different stages.

A coarse horizon may form before fine probes are completely trapped.

This last possibility would produce scale-dependent horizons.

Large wrapped probes may be trapped while primitive disturbances still leak outward through microscopic channels. Alternatively, fine probes may be absorbed while robust large assemblies remain capable of escape.

A mature black-hole interpretation requires convergence across relevant probe scales.

The transition may exhibit hysteresis. Once a horizon forms, reducing the source's historical load may not immediately restore escape because the trapped interior has reorganized into a self-maintaining state.

Such memory would make black-hole formation path-dependent.

The cube framework, with its explicit provenance and history-resolved branching, is well suited to detect this behavior.

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49. Topology Change Through Manifest and Latent Conversion

Missing cubes can generate cavities and tunnels. Latent cubes can generate hidden relations. Their interaction permits changes in effective connectivity.

A manifest region may develop a vacancy channel that joins two previously separated domains.

A latent relation may become manifest and expose a new interface.

A manifest tunnel may collapse into a latent constraint structure.

A bridge may lose geometric traversability while retaining EPR-like correlation.

A trapped region may divide into two horizons connected by a shared latent interior.

Two horizons may merge and erase their prior separation.

These transformations represent changes in operational topology.

The primitive ledger need not describe a space changing topology. It records occupancy, contact, reachability, wrapping, and relational continuity before and after the transition.

A topology-change-like interpretation is justified when no continuous family of ordinary local rearrangements at the chosen descriptive level connects the two states without passing through a critical vacancy, horizon, or latent conversion.

The cube ontology offers several distinct notions of connection:

manifest contact;

manifest reachability;

vacancy passage;

latent relational continuity;

wrapped common interior;

causal accessibility.

A system may be connected under one notion and disconnected under another.

An EPR bridge is especially revealing. The exterior domains may be manifestly disconnected through the bridge, causally unable to exchange controlled signals, yet connected through a shared latent assembly.

Thus the question “Are the two regions connected?” has no unique answer until the operational relation is specified.

Mature geometry often compresses these relations into one spatial picture. The cube genesis ledger keeps them separate long enough to discover which combinations support which physical phenomena.

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50. Toward a Cube-Based Quantum Gravity

The present construction does not yet constitute quantum gravity.

It provides a common substrate from which gravity-like and quantum-like ancestors may arise.

Gravity-like structure comes from the deformation of local continuation, propagation, clocks, and reachability by persistent histories.

Quantum-like structure comes from branching, latent intermediate states, relational histories, contextual probes, and joint constraints that cannot be reduced to independent manifest states.

The important possibility is that these structures are not added as separate layers.

The same latent and historical mechanisms may contribute to both.

A source assembly modifies surrounding continuations partly through latent mediation.

A horizon is defined through the complete branching structure of future histories.

Emission may divide a relational latent state across inward and outward descendants.

An EPR pair may become the two boundary interfaces of one concealed assembly.

Effective geometry may arise as the coarse description of distributed relational histories.

This suggests that geometry and entanglement-like organization could share a common ancestry.

The cube system should therefore avoid constructing a classical gravitational world first and adding quantum rules afterward. That sequence would reproduce the conceptual division already present in mature physics.

Instead, the primitive update engine should generate manifest, latent, missing, branching, and relational behavior together.

Classical-like geometry should emerge only in regions where branching and latent structure become sufficiently stable or compressible to support one common continuation description.

Quantum-like behavior may remain visible where several continuations resist such compression.

A black hole would then be a regime in which effective geometry, extreme causal organization, and inaccessible relational branching meet.

An EPR bridge would not connect two preexisting points of spacetime. It would be one of the structures from which the effective relation between those regions is reconstructed.

The program's most ambitious conjecture can therefore be stated:

Spacetime-like geometry is the coarse operational form of provenance-organized possibility.

Persistent manifest histories determine which local possibilities survive.

Latent histories preserve relations absent from present manifestation.

Structured absences constrain connectivity and boundaries.

Recursive wrapping converts these relations into higher-order interfaces.

Observers reconstruct geometry from the resulting accessibility of histories.

Gravity is the deformation of that accessibility.

Black holes are its self-trapped regions.

EPR bridges are its concealed relational continuities.

51. The Fundamental Object Is the Admissible History

The construction developed so far suggests that the individual cube may not remain the most fundamental physical object.

A cube carries marks, orientation, contact relations, latent capacities, vacancy surroundings, and provenance. Yet none of these alone determines its physical significance. What matters is the set of histories the cube can enter, preserve, alter, or prohibit.

The primitive physical object is therefore better described as an **admissible history structure**.

At any recorded stage, the world contains more than one realized state. It contains a locally generated organization of possible next events. Some continuations preserve a pattern. Some destroy it. Some transmit it. Some convert it into latency. Some create structured absence. Some branch into several distinct futures.

The realized history selects one continuation, but the unrealized admissible alternatives remain important because horizons, causal order, and EPR-like constraints depend on the complete possibility structure rather than on one observed trajectory.

A horizon exists because no admissible future from the interior reaches the exterior.

An EPR relation exists because the admissible joint histories of two endpoints cannot be decomposed into independent endpoint histories.

A gravitational field exists because the admissible continuations of many different probes are modified in one common regional pattern.

A bridge exists because two apparently separate continuation domains belong to one concealed higher-order history structure.

This changes the interpretation of the cube substrate.

The cubes are not little pieces of preexisting space.

They are finite carriers of possible continuation.

Contacts determine which continuation structures can interact.

Wrapping creates new units of admissibility.

Latency preserves operative possibilities not present in the manifest state.

Absence removes possibilities, redirects them, or creates boundaries among them.

Physical geometry becomes a recognition of the organized relations among admissible histories.

This proposal extends the source papers rather than restating them. The papers establish history-bearing cells, bounded propagation, distributed transition conditions, structured absence, recursive wrapping, and delayed recognition. The stronger claim that admissible history is ontologically prior to effective geometry is a new conjecture developed here. The source framework nevertheless makes that conjecture possible because it treats fields as distributed conditions modifying local transitions rather than as quantities assigned to an already interpreted space.

The relation can be stated compactly:

cube state
→ local admissible continuations
→ history structure
→ effective causal order
→ effective geometry

The familiar image of objects moving through spacetime is therefore reversed.

Objects and spacetime are both compressed descriptions of recurrent organization within the same field of admissible histories.

An object is a persistent bundle of histories.

A location is a class of operationally related event contexts.

A path is a sequence of mutually admissible local continuations.

A clock is a recurrent history used to compare other histories.

A gravitational source is a persistent history that reorganizes nearby admissibility.

A black hole is a self-maintaining region of one-way admissibility.

An EPR bridge is a concealed joint admissibility structure with separated manifest interfaces.

This shared basis may explain why gravity, causality, information, and entanglement-like behavior become inseparable near black holes. They are different recognition-level descriptions of one underlying organization.

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52. Gravity as a Failure of Independent Continuation

In a source-free reference region, two sufficiently separated persistent histories may evolve approximately independently. Their combined future can be reconstructed from their individual futures except when their propagation neighborhoods eventually overlap.

A source-like assembly disrupts this independence.

The source modifies local transition conditions, those modifications propagate, and histories that would otherwise evolve independently become constrained by one common regional organization.

Gravity can therefore be characterized as a systematic failure of independent continuation.

This statement does not mean that every event becomes directly connected to every source cube. The dependence remains locally mediated. Yet the large-scale result is that a probe's future cannot be predicted from the probe alone. The surrounding source-conditioned history structure must be included.

The context ladder from the original cube framework becomes a gravitational diagnostic. A narrow description containing only the probe fails. Adding its immediate neighbors may improve prediction. Adding a larger source-conditioned region may eliminate the remaining branching. The minimum sufficient context defines the operational range of the deformation.

Several dependence regimes may be distinguished.

In a weak region, source information is needed only for small corrections to probe histories.

In a stronger region, the source-conditioned environment determines which broad path family survives.

Near a horizon, the environment determines whether outward continuation exists at all.

Inside a trapped region, the exterior and interior can no longer be treated as independently accessible continuation domains.

Across an EPR bridge, two distant endpoint records require a shared latent context even though no ordinary manifest propagation links the measurements during their separation.

Gravity and EPR-like relation thus appear as different failures of factorization.

Gravity is primarily a failure to factor a local object from its surrounding continuation structure.

EPR-like relation is primarily a failure to factor one endpoint history from another.

A bridge-like black-hole pair combines both failures.

Each endpoint is inseparable from its source-generated geometry.

The two interiors are inseparable from their shared relational provenance.

The combined object therefore resists decomposition both spatially and historically.

This suggests a new unification criterion. A candidate quantum-gravitational cube world should not merely contain gravity-like and EPR-like phenomena. It should generate them through related failures of independent continuation.

The relevant question becomes:

Under what anonymous local rules does persistence create nonfactorizable history?

One answer may involve shared latent records.

Another may involve constrained branch conservation.

Another may involve recursive wrapping that turns several histories into one externally presented unit.

Another may involve structured absence that prevents the independent completion of local contexts.

The search should determine whether one compact mechanism produces both gravitational sourcehood and relational entanglement.

If so, geometry and EPR structure would share more than a metaphorical connection. They would arise from one primitive obstruction to independent history.

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53. Curvature as Noncommuting Transport History

The earlier discussion defined curvature-like behavior through path deviation, altered return times, and common probe deformation. A stronger operational criterion can now be proposed.

Take a stable cube assembly and transport it through a closed sequence of neighboring contexts. At each stage, preserve its operational identity as fully as the local rules permit. After returning to the initial manifest address, compare its orientation, internal cycle, latent register, vacancy relation, and complete probe signature with the starting record.

If the transported assembly returns unchanged in the reference world but returns altered in a source-conditioned region, the closed transport history contains a residual.

The residual may depend on the path.

One loop may produce no change.

Another loop enclosing a persistent source may produce an orientation shift, clock discrepancy, latent phase difference, or transformed interface signature.

This provides a route toward curvature-like recognition without beginning from coordinates, tangent vectors, angles, or a metric.

The primitive fact is:

return to the same address does not imply return to the same operational state.

The difference has been accumulated through transport history.

The system should compare alternative orders of local displacement procedures. Suppose procedure A followed by procedure B reaches the same final address as procedure B followed by procedure A. If the resulting transported states differ, the two displacement histories do not commute operationally.

Such noncommutation is especially significant when it is:

reproducible;

source-dependent;

shared across diverse transported probes;

stable under refinement of the path;

compressible into a common regional signature.

The recognition ledger may later compare the residual with curvature or holonomy-like structure.

The cube model therefore provides two complementary definitions of effective curvature.

The first is **continuation curvature**: common bending and delay of propagating histories.

The second is **transport curvature**: residual transformation after closed transport.

A convincing gravitational world should connect them. Regions that deflect paths and alter clocks should also produce corresponding transport residuals. If the two structures vary independently, the effective geometry may require more than one descriptive field.

This section is a new extension. The source papers support reorientation, reproducible transport-like action, transformation history, and curvature-like recognition from differing paths and return times, but they do not supply a completed transport-curvature construction. The present proposal turns those ingredients into a specific experimental test.

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54. The Cube Equivalence Principle

The strongest gravitational threshold can now be expressed as an operational equivalence principle.

Consider a small observer assembly enclosed within a bounded laboratory region. The observer possesses internal clocks, probe emitters, memory, and comparison procedures. The laboratory is sufficiently small that the source-conditioned regional deformation varies only slightly across it.

Two situations are prepared.

In the first, the laboratory follows a free history through a source-deformed region.

In the second, the laboratory occupies a reference region but undergoes a direct sequence of local interface transformations designed to reproduce the same internal records.

The observer attempts to distinguish the situations using only experiments confined to the laboratory.

An equivalence-like principle emerges when no permitted local probe distinguishes them within a defined resolution and duration.

The system should not program their equivalence. It should search for pairs of histories whose complete internal operational signatures coincide despite different external provenance.

The result would mean that a sufficiently small observer cannot locally separate gravitational continuation from a corresponding acceleration-like history.

At the genesis level, the two laboratories remain distinct. Their construction records differ.

At the observer level, they are indistinguishable under the available local probe set.

At the recognition level, the equivalence may justify interpreting gravity as geometry rather than as an ordinary force.

The principle is necessarily scale-limited. A larger laboratory may detect differences across its extent. Longer observation may reveal divergent external histories. A sufficiently sensitive probe may detect substrate anisotropy.

The cube equivalence principle should therefore be stated with an explicit aperture:

Two histories are equivalent relative to observer O, probe family P, region size R, and history depth D when their internal operational signatures agree under all tests in P through D.

This avoids turning equivalence into an unsupported absolute identity.

A hierarchy may then emerge.

Some source regions support equivalence only for one probe family.

Some support it for all passive matter-like probes.

Some support it for clocks and waves as well.

Some support it across several wrapping levels.

The broadest regime earns the strongest gravitational interpretation.

The source framework emphasizes that indistinguishability must always be qualified by the probe set and that recognition may later refine or split previously grouped objects. The cube equivalence principle follows that epistemic discipline.

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55. The Horizon as a Provenance Separator

A horizon separates more than locations. It separates access to provenance.

Outside the horizon, an observer may trace a received signal backward through a chain of manifest interactions. The reconstruction may be incomplete, but the source history remains connected to the observer through outward-propagating records.

Inside the horizon, events continue to possess full genesis provenance, yet no ordinary outward history carries that provenance to the exterior.

The horizon therefore divides:

provenance that remains globally recorded;

provenance that remains physically active inside;

provenance that is accessible outside.

These distinctions are not equivalent.

The complete ledger may know exactly what occurred inside.

An infalling observer may interact with some of those histories.

An exterior observer may receive only compressed boundary consequences.

The horizon is thus a **provenance separator**: a dynamically generated interface across which causal accessibility to construction history becomes asymmetric.

This interpretation clarifies why black holes are natural sites of information conflict. The underlying cube architecture insists that provenance remain complete, while the generated causal structure prevents that provenance from being shared equally among observers.

The tension is not between information and destruction at the outset.

It is between complete generation and partial accessibility.

An EPR bridge may preserve provenance across two concealed interiors even when neither exterior can read it independently. The shared relational record becomes a third location of historical identity—not a spatial location, but a provenance domain.

This yields four possible destinations for an incoming history:

manifest exterior retention;

concealed interior retention;

horizon compression;

relational bridge retention.

A fifth possibility is operational erasure, where the history ceases to affect any future event.

The system should track transitions among these destinations.

A black-hole information analysis that counts only manifest cubes will miss latent and relational retention.

An analysis that counts the external implementation log will falsely treat physically dead records as active.

The correct unit is the operationally consequential distinction.

The horizon becomes physically informative when it transforms how such distinctions can be accessed, combined, and propagated.

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56. EPR Bridges as Provenance Shortcuts

Although a nontraversable EPR bridge does not shorten manifest signal travel, it may shorten the description of joint provenance.

Without the bridge, the complete relation between two endpoint histories might require tracing both lineages back through a vast manifest network to their common origin.

With a promoted relational assembly, the same joint history can be represented by one compact object L[A,B].

The bridge is therefore initially a **provenance shortcut**.

This shortcut is descriptive but operationally consequential. The relational object predicts joint outcomes more efficiently than two independent endpoint descriptions plus a reconstructed remote past.

Recursive wrapping promotes this shortcut into a new unit. The long shared history becomes one concealed assembly with two exposed interfaces.

At a still higher level, that assembly may acquire its own internal adjacency, cycles, defects, and effective geometry.

The bridge interior can therefore grow from compression.

The sequence is:

long shared history
→ promoted relational record
→ wrapped two-interface object
→ internally structured latent assembly
→ effective bridge interior

This route avoids inserting an extra spatial tunnel into the primitive world.

The bridge is born as a compact representation of inseparable provenance. Geometry appears only after the relational representation develops enough internal structure to support path, clock, and transport-like tests.

The original mathematical paper explicitly treats promotion and recursive wrapping as means by which recurrent behavior becomes a new reusable object and higher levels arise from prior constructions. It also allows one anonymous structure to support several later recognitions.

The bridge proposal is a direct physical use of that architecture.

At the beginning, L[A,B] is simply a record required to reproduce the pair.

Later, it becomes an object participating in further encounters.

Still later, it may support a geometry-like recognition.

This developmental account explains why an EPR bridge need not resemble a classical wormhole microscopically. The classical interior is a late compression of a deeper relational ancestry.

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57. When Does a Bridge Become Spatial?

A hidden relational assembly should be called spatial only after it supports operations analogous to those used to reconstruct the exterior geometry.

The bridge must contain distinguishable internal contexts.

Patterns must be able to undergo ordered local transformations among those contexts.

The number of required transformations must define a reproducible separation-like structure.

Internal clocks must be transportable or comparable.

Alternative paths must exist.

Some paths must be deformable into one another while preserving endpoints.

Others may be obstructed by latent defects or structured absences.

Closed transport may produce residual transformations.

Different observers must reconstruct compatible relations among bridge histories.

Until these conditions hold, the bridge is relational but not geometrical.

A minimal bridge may contain only one indivisible shared constraint. It has two interfaces but no meaningful internal depth.

A more developed bridge may contain a sequence of latent stages. It has depth but perhaps only one path.

A still richer bridge may contain branching internal routes, cycles, and persistent defects. It begins to support topology-like and geometry-like description.

The bridge becomes effectively spatial when internal history can be compressed into relations of neighborhood, separation, path, boundary, and transport.

This provides a recognition threshold independent of visual representation.

A diagram may draw a long tunnel, but if the hidden relation has no internal operational structure, the length is decorative.

Conversely, a bridge may be spatially rich even if no external rendering shows a tunnel.

The effective bridge length may be defined initially as the minimum number of promoted local relational transformations required to connect the endpoint interfaces.

Other length-like measures may arise from clock records, probe delays, or complexity of reconstruction.

These measures may disagree at first.

A mature bridge geometry requires stable translations among them.

The same discipline applies to the exterior. The implementation array does not automatically define physical space. Spatiality is earned through propagation and transport.

Thus both exterior spacetime and bridge interior emerge by the same criterion.

They are domains in which history structure admits a stable geometrical compression.

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58. The Possibility of Bridge–Geometry Duality

The deepest conjecture of this paper is stronger than the existence of bridges.

It is possible that the same relational organization can be represented in two fundamentally different but operationally equivalent ways.

One description uses a network of joint latent constraints among manifest endpoints.

The other uses an effective connected interior geometry.

In the first description, correlation is primary and spatial connection is absent from the primitive vocabulary.

In the second, the same behavior is predicted by paths, boundaries, and distances inside a bridge.

A bridge–geometry duality would exist when both descriptions reproduce the complete relevant probe library and can be translated into one another.

The relational description should predict:

which joint outcomes are permitted;

which endpoint interventions alter the shared state;

which local signatures remain no-signaling-like;

how correlations change under accretion, emission, and horizon deformation.

The geometric description should predict:

which internal routes correspond to those joint transformations;

how endpoint separation is represented;

why the bridge is or is not traversable;

how internal clocks and defects behave;

how the bridge changes when endpoint horizons change.

The translations need not preserve every primitive cube distinction. A duality may identify several different provenance-complete constructions that are indistinguishable under the relevant physical probes.

But it must preserve every operational distinction claimed by either mature description.

If the relational model predicts a correlation absent from the geometry, the geometry is incomplete.

If the geometry predicts a traversable route absent from the relation, it has added unsupported structure.

If both make the same predictions but organize explanation differently, they form a genuine dual recognition.

This proposal follows the recognition philosophy of the source papers. Known mathematical or physical descriptions remain aliases attached after generation, and one anonymous construction may support multiple interpretations.

The cube world may therefore produce neither geometry from entanglement alone nor entanglement from geometry alone.

It may produce an anonymous third structure from which both emerge.

That third structure is provenance-organized admissibility.

Its manifest projection appears as separated objects with constrained outcomes.

Its wrapped projection appears as a connected hidden interior.

Its causal projection appears as paired horizons.

Its informational projection appears as shared inaccessible history.

Its geometric projection appears as an EPR bridge.

The identity among these descriptions would not be imposed by notation.

It would be earned by replay equivalence.

59. Traversability as an Additional Dynamical Achievement

A bridge may be relationally real, geometrically describable, and still nontraversable.

Traversability requires more than two endpoints belonging to one concealed assembly. It requires a controlled history beginning at one exterior interface, entering the bridge structure, preserving an identifiable operational signature, and emerging into the other exterior domain.

The complete history must be generated through permitted local transitions at every level.

A direct rule that removes a pattern from A and recreates it at B is not traversal. It is teleportation inserted by the update engine.

A traversing pattern must pass through an ordered sequence of bridge contexts. Even if those contexts are latent relative to ordinary exterior observation, they must possess replayable internal transitions.

The bridge must therefore satisfy at least five conditions.

First, it must contain an internally ordered continuation structure rather than an indivisible endpoint correlation.

Second, an entering pattern must retain enough operational identity to be recognized after passage.

Third, the passage must obey the bridge's local transition rules.

Fourth, the emergence at the distant endpoint must not occur before the corresponding internal history has been completed.

Fifth, traversal must not create an operational contradiction with the exterior causal structure.

The final condition is the most difficult.

Suppose the exterior distance between A and B requires many ordinary propagation stages, while the bridge history requires fewer. A controlled traveler could then arrive through the bridge before an exterior signal.

This does not automatically produce contradiction. The bridge may redefine the effective causal relation between the endpoints. Once it becomes traversable, A and B are no longer as causally separated as the manifest exterior alone suggests.

The problem arises when bridge motion and exterior motion can be combined into a closed causal history in which an event becomes available to its own generative past.

The cube world must test this operationally rather than appeal to a preexisting theory of time travel.

For every candidate traversable bridge, the reachability engine should search for cycles in which a record returns to an earlier stage of the same observer's internal clock or alters a context already used to generate itself.

The external implementation index always moves forward. Yet an embedded causal contradiction could still arise if the generated records allow an observer to receive a message whose contents determine the earlier event that produced it.

The system should distinguish simple closed paths from paradoxical histories. A pattern may return to its initial address after many stages without contradiction. The issue is whether the returned pattern enters a context that the genesis ledger treats as causally prior to its production.

A bridge may avoid contradiction through several mechanisms.

Traversal may require more internal stages than the apparent exterior shortcut suggests.

The bridge may permit transport only in one direction.

Its endpoint clocks may be constrained so that no usable backward ordering arises.

Traversal may alter or destroy the transported pattern's capacity to influence its own source event.

The bridge may cease to exist when endpoint histories are arranged in a paradox-producing configuration.

A relational bridge may become traversable only after ordinary causal communication has already linked the relevant endpoint stages.

These restrictions should not be declared in advance. They are candidate emergent protections whose presence or absence must be measured.

Traversability is therefore not a defining feature of an EPR bridge. It is a further dynamical achievement that may or may not be compatible with the world's generated causal order.

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60. Bridge Stabilization

A concealed connection may collapse unless continuously maintained.

The bridge interior may depend on complementary latent states at its two endpoints, recurrent internal transformations, balanced vacancy structures, or synchronized horizon cycles. Disturbing any of these may break the relational continuity.

A stable bridge must resist at least small local perturbations.

The system should test stability by altering one endpoint, disturbing the concealed assembly, adding or removing historical load, changing the horizon boundary, and introducing competing relational structures.

Possible outcomes include:

temporary deformation followed by repair;

permanent change in bridge depth;

loss of correlation while geometric continuity remains;

loss of effective geometry while relational correlation remains;

division into several weaker bridges;

collapse into ordinary manifest disconnection;

conversion of latent structure into emitted patterns;

growth of a new trapped region inside the bridge.

These outcomes reveal that “the bridge” may contain several independently stable layers.

The shared provenance may survive even after active correlation disappears.

The correlation may survive after any spatial interpretation becomes unusable.

The effective geometry may remain while the endpoint relation becomes approximately classical.

The horizons may persist after the concealed connection has been destroyed.

A complete bridge state therefore requires several signatures:

provenance continuity;

joint constraint;

internal transition structure;

effective geometric behavior;

causal accessibility;

endpoint horizon organization.

Stability must be tested separately for each signature.

A bridge may also be self-stabilizing. Perturbations at one endpoint may trigger latent compensations distributed through the concealed assembly. Missing cubes may move to repair internal defects. Wrapped subassemblies may reconstruct damaged interfaces. Internal cycles may restore endpoint compatibility.

Such behavior would make the bridge a persistent physical object rather than a static relation.

The source papers already treat reconstructive persistence and repair after disturbance as important criteria for physical identity and generative fertility. The present extension applies those criteria to relational interiors.

Bridge stabilization may require historical load of its own. Maintaining the connection may modify nearby continuation structure and therefore contribute gravitationally.

A sufficiently complex bridge could become a source.

Its interior relational activity might alter the horizons that expose it.

The geometry and relation would then be dynamically coupled rather than passively equivalent.

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61. Bridge Collapse and Correlation Release

When a bridge loses stability, its stored relational structure must go somewhere or become operationally erased.

Several collapse classes are possible.

In **silent collapse**, the shared latent relation ceases and no future generated event retains a distinguishing trace. The bridge's relational information is physically erased.

In **endpoint deposition**, each endpoint receives a residual manifest or latent state. The prior joint relation becomes two local memories.

In **asymmetric deposition**, one endpoint retains most of the operational signature while the other returns to a neutral state.

In **radiative release**, the bridge emits propagating patterns into one or both exterior domains.

In **horizon absorption**, the relational structure is incorporated into the microscopic state of one or both horizons.

In **topological conversion**, the concealed relation becomes an ordinary manifest passage or vacancy tunnel.

In **bridge fission**, one relation becomes several weaker relational structures among new endpoint pairs.

These possibilities should be constrained by independently discovered invariants. A bridge carrying a conserved relational opposition cannot disappear without transferring or cancelling that opposition through an allowed process.

Bridge collapse could also provide a mechanism for converting inaccessible relational history into exteriorly observable patterns.

If the emitted patterns depend on the bridge's prior state, exterior observers may partially reconstruct the concealed relation.

If the emissions depend only on coarse endpoint signatures, fine bridge information remains hidden or erased.

The system should compare initially distinct bridges with identical endpoint exteriors and determine whether their collapse products differ.

This experiment parallels the black-hole information test but focuses on relational interiors.

Bridge collapse may also alter effective distance. Two exterior regions that were operationally close through the bridge suddenly become distant under the remaining manifest network.

Embedded observers may reconstruct this as a rapid change in geometry.

At the genesis level, the event is a change in available continuation channels.

The bridge therefore makes geometry explicitly developmental. Connectivity can be born from shared history and lost when that history ceases to remain active.

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62. Measurement as Interface Transformation

The cube framework should avoid treating measurement as a primitive mystical intervention.

A measurement-like event is an encounter between a probe-bearing observer and a target history through a selected interface. The encounter creates a persistent record in the observer and may alter the target, the probe, or their relational latent state.

Different measurements correspond to different reading apertures, orientations, contact patterns, and replacement procedures.

A panel-sensitive probe may expose one operational distinction.

A seam-sensitive probe may expose another.

A junction-sensitive probe may expose a third.

A wrapped-interface probe may access a collective property invisible at primitive sites.

The incompatibility of measurements may emerge when applying one probe changes or destroys the context required by another.

This provides a natural route toward contextual behavior.

A target does not necessarily carry a complete manifest list of answers to every possible probe. Its response may be generated jointly by the target history, the selected interface, the probe history, and an active relational latent structure.

For an EPR-like pair, the joint outcome is produced through two local measurement encounters constrained by one shared relation.

The system should preserve the exact order and context of these encounters.

A claim of contextuality is justified only when no assignment of independent preexisting endpoint responses reproduces the complete family of observed joint records.

The cube architecture is especially suitable for this test because orientation and reading aperture are already primitive operational distinctions. No abstract measurement axis needs to be inserted initially.

Repeated reorientation may generate families of probes related by stable transformation cycles. The recognition ledger may later identify these families with alternative measurement settings.

The crucial methodological rule remains unchanged: the familiar quantum interpretation follows the operational pattern.

Measurement also affects bridge structure.

A local probe may consume part of the shared latent state.

It may refine one branch and eliminate others.

It may transfer relational information into observer records.

It may weaken, strengthen, or reconfigure the concealed bridge.

Thus the bridge is not necessarily a static channel existing independently of observation. It is a history-bearing relation whose state includes its interactions with observers.

This does not mean that consciousness creates the bridge. The observer is an ordinary generated assembly. Measurement is physical contact plus record formation.

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63. Branching, Selection, and the Status of Outcomes

The cube world may generate several admissible continuations from one recorded context.

The framework must decide how realized histories relate to unrealized branches without importing a mature interpretation of quantum mechanics.

Several architectures are possible.

In a **single-selection world**, one permitted branch is realized and the others remain merely admissible alternatives in the ledger.

In a **persistent-branch world**, every permitted continuation develops into a distinct subsequent history.

In a **branch-merging world**, several continuations develop separately and later become operationally indistinguishable.

In a **latent-branch world**, unrealized alternatives remain as hidden capacities influencing later outcomes.

In a **observer-relative branch world**, different generated observers retain records associated with different continuations while the global structure preserves all of them.

These architectures should be explored as alternative rule families.

An EPR bridge behaves differently in each.

In a single-selection world, the shared relational state may coordinate which joint branch becomes realized.

In a persistent-branch world, the bridge may connect corresponding endpoint branches across a larger branching assembly.

In a latent-branch world, unmanifest outcomes may remain part of the bridge interior.

In a branch-merging world, apparent information loss may occur when distinct relational histories converge.

The original physical paper explicitly permits branching outcomes and warns against prematurely identifying them with quantum behavior. The present theory preserves that caution.

Quantum-like recognition requires more than multiplicity. It requires a stable operational organization of branching, contextual probing, relational constraint, interference-like recombination, and observer records.

The cube program may discover several different branching physics.

One may resemble ordinary stochastic dynamics.

Another may resemble hidden-state determinism.

Another may exhibit contextual nondecomposability.

Another may retain all branches through recursive wrapping.

The gravitational behavior of these worlds may differ substantially.

A horizon in a single-selection world traps the realized history.

A horizon in a persistent-branch world must be defined relative to all branches. Some branches may escape while others remain trapped.

A strict horizon exists only when no admissible branch reaches the exterior.

This branch-complete definition prevents the system from calling a region black-hole-like merely because most realized trials fail to escape.

A quantum-like horizon may therefore fluctuate in branch structure even when its coarse exterior signature remains stable.

---

64. Interference-Like Reconstruction

Latent cycles and branching become more quantum-like when separated histories can later recombine and produce outcomes not predictable from ordinary mixture.

The cube system can test this without introducing amplitudes.

Begin with a manifest pattern capable of entering two distinguishable continuation channels. The channels remain separated for several updates and later meet at a common interface.

Four experiments are performed:

only channel A is available;

only channel B is available;

both channels are available but relational latency is destroyed;

both channels are available and relational latency is preserved.

If the final outcome family in the fourth experiment cannot be reconstructed from a simple combination of the first two, the joint history contains an interference-like effect.

The difference must be traced to a replayable latent or relational structure connecting the channels.

Some final branches may be reinforced because two transformation histories converge with compatible latent phases.

Others may be suppressed because the histories carry operationally opposed latent states.

The earlier physical paper proposes four-stage latent cycles, opposition, cancellation, reinforcement, and phase-sensitive encounters as possible ancestors of complex-like physical structure.

The present construction applies those resources to branching propagation.

Interference-like behavior becomes especially significant for EPR bridges. A relational interior may contain several hidden routes connecting the endpoints. Joint endpoint outcomes could depend on how these routes recombine.

The bridge's effective geometry would then encode not merely connectivity but phase-sensitive history structure.

Two bridges with the same coarse connectivity could produce different correlations because their latent transport cycles differ.

This would show that geometry alone is insufficient. The bridge requires additional relational structure.

Conversely, a richer geometry-like description might absorb those distinctions through orientation, internal cycles, or connection-like data.

The recognition ledger should determine whether the latent structure remains an independent physical field or becomes part of the effective bridge geometry.

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65. From Complex-Like Cycles to Propagating Phase

A four-stage latent cycle may supply more than an isolated transformation analogy.

If such cycles are carried by propagating patterns, each history may possess an internal stage relative to its own recurrence.

Two patterns with identical manifest shapes may therefore interact differently because their latent cycle stages differ.

The manifest description alone would treat them as identical.

The history-complete description distinguishes their phase-like states.

Propagation through a source-deformed region may alter the number of latent cycle stages accumulated along a path. Two paths beginning and ending at the same manifest contexts may produce different final latent stages.

When the histories recombine, their compatibility or opposition may affect the resulting branch family.

This provides a common operational basis for several phenomena:

clock comparison;

wave-like propagation;

interference-like reconstruction;

closed-transport residuals;

source-dependent phase accumulation;

bridge-internal relational structure.

The same latent-cycle machinery could therefore participate in both gravitational and quantum-like behavior.

A source-conditioned region may alter phase accumulation because it inserts additional latent stages or changes local transition ordering.

The resulting phase difference may be another record of effective curvature.

A bridge may preserve phase relations between separated endpoints because they remain parts of one latent assembly.

A horizon may conceal phase information while transferring part of it to emitted patterns or bridge partners.

This cross-domain reuse is exactly the kind of generative fertility the cube program seeks. One primitive mechanism produces several mature recognitions without being designed under any one of their names.

The system should search for compact cycles of all lengths, not only four. The four-stage case is especially suggestive because it supports paired manifest and latent opposition, but the anonymous exploration must not privilege it solely for resembling complex numbers.

Different worlds may generate different phase structures.

Some may support finite cycles.

Some may support several coupled cycles.

Some may support nonclosing recurrent histories.

Some may generate phase only at higher wrapped levels.

The resulting physics may differ from familiar quantum theory while remaining coherent.

The recognition ledger must record both correspondence and surplus.

---

66. The Emergence of an Action-Like Principle

A mature physical world often permits the actual histories of objects to be summarized through a compact global principle. The cube program must not assume such a principle, but it can search for one retrospectively.

Every realized history has a complete primitive record. It contains the number and type of replacements, latent stages, vacancy movements, interface changes, repair operations, branch restrictions, wrapping transitions, and clock cycles.

The system may assign no prior physical meaning to these features. It can nevertheless ask whether realized persistent histories systematically minimize, maximize, or stationarize some compressed record relative to nearby admissible alternatives.

Suppose many possible paths connect two operational contexts.

The realized stable path may require the fewest disruptive replacements.

It may preserve the largest invariant signature.

It may minimize latent mediation.

It may balance several competing transition costs.

It may be locally unchanged under small path substitutions even when it is not globally minimal.

If one compact path score predicts propagation across many source regions and probe families, an action-like description has emerged.

The score must be discovered from the histories rather than chosen because it reproduces known trajectories.

The search procedure may compare thousands of successful and unsuccessful paths and identify combinations of ledger features that separate persistent realized continuations from unstable alternatives.

A candidate principle is strong when:

the same score applies across several object families;

it predicts both reference and source-deformed propagation;

it reproduces clock and phase accumulation;

it remains valid under recursive wrapping;

it generates horizon behavior as a limit of admissible paths;

it extends to bridge-internal histories.

The score may initially be a discrete record rather than a number. It could be a canonical ordering of histories based on several criteria.

Only later may a scalar compression become possible.

An action-like principle would provide a powerful recognition bridge between local cube updates and global effective physics.

The primitive world remains local and constructive.

The mature description predicts entire histories through one compact extremal rule.

This would be a genuine emergent law: not inserted into the update engine, but discovered as a regularity among the histories produced by it.

67. Toward an Emergent Field Equation

The cube world may eventually support a compact relation between source organization and continuation deformation.

Such a relation should not be inserted into the primitive update rules. It must be inferred from many generated histories involving different sources, probes, clock assemblies, orientations, and wrapping levels.

The source side of the relation may include several anonymous operational signatures:

persistence depth;

internal recurrence;

repair activity;

latent-stage burden;

vacancy imbalance;

wrapping complexity;

boundary activity;

resistance to changes in propagation;

transferable invariant content.

The geometry side may include:

probe deflection;

propagation delay;

clock divergence;

closed-transport residuals;

reachable-history deformation;

branch funneling;

horizon formation;

outward disturbance propagation.

The system should first determine whether one small family of source signatures predicts one small family of deformation signatures.

If every type of source requires an unrelated descriptive law, no unified gravitation has emerged.

A stronger result occurs when apparently different source organizations produce the same exterior deformation whenever their coarse source signatures agree.

This would mean that the detailed internal cube construction is irrelevant to large-scale gravitational behavior.

The source has been compressed into an effective load.

Likewise, the deformation may admit several descriptions. Probe bending, clock alteration, causal reachability, and transport residuals may initially appear independent. If one regional structure predicts all of them, they become components of one effective geometry.

An emergent field relation would connect these two compressions:

coarse source organization
→ coarse continuation geometry

The arrow should not be assumed to be one-directional.

The source persists only within the continuation structure of its surroundings. Altering the geometry-like organization may change the source's stability, clock cycles, and permitted internal histories. Source and geometry therefore form a coupled system.

The mature relation may take the form:

source organization constrains geometry;

geometry constrains source continuation.

At the genesis level, both directions remain local cube updates.

At the recognition level, they may be summarized by a compact mutual law.

The theory should not demand that this law initially resemble any familiar equation. It may be discrete, conditional, history-dependent, multivalued, or valid only after coarse wrapping.

The crucial requirement is explanatory economy. One relation should predict a broad class of generated gravitational phenomena more successfully than separate descriptions of every local encounter.

---

68. Local Conservation and Source Continuity

A source-like assembly should not appear, disappear, or change its exterior influence arbitrarily.

The cube world already searches for invariant signatures preserved across significant classes of updates. These signatures may be transferred between regions, concealed in latent structures, carried by vacancies, or redistributed during encounters.

A gravitational source signature becomes physically credible when its changes obey corresponding transfer rules.

Suppose a persistent assembly divides into two descendants. The total source-like effect of the descendants may equal that of the parent, perhaps with part transferred into an emitted disturbance or latent relation.

Suppose two assemblies merge. Their combined exterior deformation may depend on a preserved aggregate signature rather than on an arbitrary reset.

Suppose an assembly emits a propagating pattern. Its source signature may decrease by an amount correlated with the emitted history.

Suppose a manifest source becomes latent. Its exterior influence may persist, change form, or be transferred to a concealed assembly.

The system should search for a continuity-like rule connecting changes in localized source signatures with propagating changes in surrounding transition structure.

A source cannot diminish in one region without some corresponding history leaving that region, becoming latent, being transferred to a boundary, or being annihilated against an operational opposite.

This condition prevents gravitational influence from changing through unexplained global revision.

The primitive mechanism remains local. A source changes its immediate interface. That interface changes its neighbors. The modification propagates outward through finite stages.

At the recognition level, the history resembles a conservation and continuity law.

The strongest result would connect source conservation with the effective field relation. The same invariant that predicts the exterior deformation would also obey local transfer and balance.

Such unity would justify interpreting the source signature as a mass-energy-like quantity rather than as an arbitrary measure of structural complexity.

The system may instead discover several independently conserved source signatures, each producing a different component of continuation deformation.

That result must also be retained. A single universal source quantity is a discovery target, not an axiom.

---

69. Coordinate Freedom Without Prior Coordinates

The implementation must assign addresses to cubes and events so that histories can be replayed. These addresses are indispensable for the genesis ledger, but they should not automatically become physical coordinates.

Different address conventions may describe the same operational world.

One implementation may number cubes by rows, columns, and layers.

Another may identify them through construction trees.

A third may use dynamically changing neighborhood labels.

A fourth may assign addresses relative to a generated observer.

If all observable cube histories translate consistently among these encodings, the address choice is representational rather than physical.

A covariance-like principle emerges when the mature laws of the generated world depend only on operational relations and not on arbitrary ledger coordinates.

This should be tested directly.

Take one complete world history and rewrite it under a different reversible addressing convention. Reconstruct all contacts, updates, probe histories, clocks, horizons, and bridge relations. The recognition-level physics should remain unchanged.

A stronger test applies dynamically altered coordinate descriptions. An observer may define addresses relative to its own transported frame. Another may use a distant reference assembly. Their records may assign different coordinates and update times to the same events.

The theory should generate explicit translation procedures between these records.

The source paper already permits different observers to reconstruct related but nonidentical temporal descriptions and treats systematic translations among observer records as a requirement for observer-relative physics.

The gravitational extension broadens this requirement.

Observers should be able to use different internal coordinate constructions while agreeing on operational invariants such as:

whether two events can influence one another;

whether a probe escapes a trapped region;

whether two clocks reunite with different cycle counts;

whether a closed transport produces a residual;

whether two endpoints remain relationally constrained.

Coordinates may change.

The admissible-history structure must not.

This provides a cube-native route toward general covariance. The mature theory is not tied to the visual cubic lattice, even though the implementation uses cubes.

The cube is the generative carrier.

It need not remain the privileged coordinate system of the generated physics.

---

70. The Metric as a Compression of Clock and Signal Records

A metric-like structure should not be defined by assigning numbers to pairs of cube addresses.

It should be reconstructed from operational comparisons.

Observers can exchange propagating signals.

They can transport clocks.

They can compare recurrence counts.

They can measure the minimum update depth required for one event to influence another.

They can record round-trip histories.

They can compare different paths between the same endpoint contexts.

From these records, a compact separation structure may emerge.

Two nearby contexts are operationally close when signals and persistent patterns can pass between them through short, stable histories.

They are operationally distant when communication requires many stages, extensive latent mediation, or rare continuation branches.

A source-conditioned region alters these relations.

A pair of fixed implementation addresses may become operationally farther apart because propagation requires more history.

Another pair may become effectively closer through a wrapped or latent interface.

The system should determine whether one common separation assignment predicts:

signal travel histories;

clock comparisons;

free probe propagation;

closed-path records;

causal accessibility.

If so, that assignment has earned a metric-like interpretation.

It need not be primitive or exact.

Different probe families may initially reconstruct slightly different effective separations.

At larger wrapping scales, their descriptions may converge.

The degree of convergence provides a measure of how successfully one geometry compresses the underlying cube physics.

Near horizons or deep bridge interiors, no single smooth metric-like description may suffice. Branching, latency, and discrete fluctuations may remain irreducible.

The theory should therefore allow geometry to have a domain of validity.

A metric is not the world itself.

It is a successful compressed summary of certain histories under certain probes and scales.

This interpretation preserves the source program's distinction between anonymous generation and later mathematical recognition. Geometry enters only after signal, clock, and transport behavior have generated the structure that geometry summarizes.

---

71. The Limit of a Smooth Gravitational Description

A smooth effective geometry will eventually fail when probes resolve the primitive history structure too finely.

Several forms of failure are possible.

Propagation may reveal preferred cube directions.

Clock ratios may fluctuate rather than converge.

Closed-transport residuals may depend sensitively on microscopic path details.

Different probe families may reconstruct incompatible geometries.

The horizon may possess holes that appear and disappear across individual updates.

Latent bridge stages may resist localization.

Branching may remain essential rather than compressible into one trajectory.

These failures should not automatically be treated as defects in the implementation.

They may define the scale at which the gravitational description ceases to be fundamental.

Below that scale, the world is not a smooth geometry containing cubes.

It is a history-generating cube system from which geometry can no longer be cleanly extracted.

This provides an operational meaning for a quantum-gravitational regime.

The regime begins where:

one effective path must be replaced by several admissible continuations;

one clock rate must be replaced by a branching family of cycle histories;

one local geometry must be replaced by probe-dependent transition structure;

one definite horizon must be replaced by fluctuating trapping contexts;

one bridge interior must be replaced by distributed relational latency.

The breakdown scale need not be universal.

It may depend on the source, probe resolution, wrapping level, and observer construction.

Strongly deformed regions may reveal substrate structure at larger scales than weak reference regions.

Black-hole horizons and bridge throats are likely locations for such failure because they concentrate causal, latent, and boundary organization.

The theory should therefore resist the temptation to force every cube history into a continuous geometry.

The failure of geometric compression may itself be the principal signature of the deeper substrate.

---

72. Singularities as Failures of Recognition

A continuum gravitational description may predict a region in which its own quantities become unbounded or undefined.

The cube substrate contains only finite marks, finite local contexts, finite histories at each recorded stage, and finite assemblies before further wrapping. It therefore need not contain literal infinities.

What appears as a singularity at the recognition level may correspond to a failure of the coarse geometric description.

Several cube-level structures could produce such failure.

Recursive wrapping depth may increase without settling into a stable coarse scale.

Local continuation may branch faster than the recognition system can compress it.

Clock comparisons may cease to converge.

All outward histories may terminate while internal update complexity continues to grow.

Distinct probe families may reconstruct incompatible effective geometries.

The number of operationally relevant latent stages may increase without a bounded summary.

A source assembly may enter a terminal rule context in which no permitted next state exists.

A region may lose the stable neighborhood structure required for metric reconstruction.

These behaviors are severe, but none is an infinite density by definition.

The recognition ledger may describe them as singularity-like only when the previously successful geometry becomes incomplete or nonextendable there.

The cube ledger remains authoritative. It records what actually happens.

This distinction separates two questions.

Does the effective gravitational description become singular?

Does the underlying cube world cease to generate valid histories?

The first may occur without the second.

If the cube histories continue, the singularity has been resolved ontologically even if it remains a boundary of the effective geometry.

If the histories terminate, the world contains a genuine endpoint of development.

If recursive internal construction continues indefinitely, the region may be complete in generation but inaccessible to finite observers.

The system should not assume that discreteness automatically removes every pathology. A finite local alphabet can still generate unbounded recursion, computational nontermination, or irreducible branch growth.

The advantage of the cube framework is not guaranteed regularity.

It is exact provenance concerning what replaces the failed geometric description.

---

73. Black-Hole Interiors as Recursive Worlds

A black-hole interior may support further levels of organization.

Once causally concealed, its cube assemblies can continue interacting, wrapping, branching, generating latent structures, and forming internal observers. Exterior inaccessibility does not imply interior simplicity.

The interior may therefore become a world within the world.

Its effective geometry need not resemble the exterior geometry.

Its operational dimension may differ.

Its clocks may follow different comparative relations.

Its internal address structure may expand through recursive wrapping even while its exterior horizon remains approximately fixed.

Its histories may generate further trapped regions.

A black hole may contain black-hole-like substructures.

An EPR bridge may connect one internal region to another exterior or interior domain.

This possibility follows naturally from the recursive closure of the cube ontology. Any stable finite assembly may be wrapped and reused as a new cell. There is no predetermined highest level.

The exterior observer may describe the black hole through a small boundary signature.

The internal observer may experience a complex developing world.

Both descriptions can be valid under their respective reading apertures.

This suggests a radical interpretation of apparent interior volume.

Interior size may not correspond to the number of primitive cubes visually enclosed by the horizon.

It may correspond to the amount of recursively generated history accessible behind the boundary.

A small exterior interface could conceal an enormous internal construction tree.

The cube framework therefore distinguishes material enclosure from generative depth.

A black hole may be externally compact but internally vast because recursive wrapping creates new operational scales.

The bridge between two horizons may likewise be long in generative depth while the endpoint relation remains compact in the exterior description.

This provides another route toward the mismatch between boundary size and interior complexity.

The theory must test whether such recursive interiors remain dynamically coupled to the horizon. If internal developments can never alter any future boundary or relational state, they may be physically isolated worlds. If they do affect the horizon, exterior probes may recover coarse evidence of their evolution.

---

74. Cosmological Expansion From Changing Admissibility

The cube framework may also support an expansion-like universe without moving cubes through a preexisting external space.

Suppose persistent large-scale updates progressively alter the number of intermediate histories required to connect distant regions.

Two observer assemblies initially exchange signals through a certain family of paths. At later stages, the same operational exchange requires more intermediate transitions, even though neither observer has locally moved relative to nearby cubes.

Their effective separation has increased.

Expansion therefore appears as a systematic change in connectivity and clock–signal relations rather than as cubes flying outward into an empty container.

Several mechanisms could generate this behavior.

New cubes or wrapped levels may be inserted between existing operational regions.

Latent stages may accumulate along long-range paths.

Local contact networks may reorganize so that distant communication requires more steps.

Recursive wrapping may create additional internal depth while preserving local neighborhoods.

Vacancy structures may divide formerly close continuation domains.

A background transition cycle may uniformly stretch the history required for propagation.

The system should distinguish genuine large-scale expansion from ordinary source motion.

In source motion, local objects change their histories through a relatively stable background continuation structure.

In expansion, the relation among widely separated comoving-like observer histories changes even when their local environments remain approximately unchanged.

An isotropic expansion-like regime occurs when many observers reconstruct the same large-scale trend without identifying one privileged center.

The visual cube array need not expand.

The effective geometry reconstructed from signals and clocks does.

This is another example of why implementation coordinates must not be equated with physical space.

---

75. Primordial Horizons and Relational Seeds

A developing cube universe may begin in a state with no mature geometry.

Early histories may be densely relational, highly branching, and dominated by latent transformations. Stable objects, clocks, and distances may not yet exist.

As recurrent assemblies and propagation bounds emerge, portions of the world may acquire geometry-like descriptions.

Different regions may stabilize independently.

Their local clocks and continuation structures may not initially be coordinated.

Expansion-like development may then separate them faster than ordinary manifest records can be exchanged.

Causal horizons arise between regions that share an early provenance but cannot communicate during later stages.

These regions may nevertheless retain relational latent structure inherited from their common origin.

The same mechanism used to create EPR-like pairs can therefore operate cosmologically.

Large-scale correlations may survive between domains lacking later manifest contact.

The genesis ledger would record a local shared history followed by separation and causal disconnection.

A mature observer may infer the early relation only through joint statistical or structural regularities.

This provides an anonymous route toward primordial correlation without inserting action across later distance.

The system should determine whether such relational seeds influence later geometry.

A latent relation connecting large domains may alter their boundary conditions, source organization, or effective connectivity.

It may become a bridge-like structure at higher wrapping levels.

It may decay into ordinary correlation.

It may become inaccessible after horizon formation.

The distinction between a primordial EPR-like relation and a classical common-cause record depends on the same contextual tests developed for local endpoint pairs.

The cube universe should not receive quantum cosmology as an added theory.

Its early relational structure should arise from the same primitive latency, branching, and wrapping used everywhere else.

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76. Vacuum-Like Structure as Active Background

A region containing no localized persistent object need not be devoid of structure.

It may contain manifest cubes in a recurrent background state.

It may contain latent cycles.

It may contain balanced vacancy and extra-occupancy patterns.

It may contain unresolved branches.

It may possess nontrivial propagation and clock behavior.

It may continually generate and remove short-lived defects.

A vacuum-like state is therefore not the absence of cubes.

It is a recurrent background history lacking the persistent localized signatures recognized as objects.

Several vacuum-like states may exist.

They may differ in latent organization, symmetry, propagation speed, branch structure, or capacity to support particular persistent patterns.

An interface between two vacuum-like states could itself become a physical object.

A black-hole horizon may separate an exterior vacuum regime from a distinct concealed continuation regime.

A bridge interior may constitute another vacuum-like phase of the cube world.

The system should search for the most stable low-structure recurrent backgrounds generated by each rule family. These backgrounds provide the reference against which source deformation is measured.

The choice of reference vacuum cannot be arbitrary. It should be selected through dynamical persistence, broad accessibility, and minimal localized historical load.

Vacuum fluctuations, in cube language, are temporary departures from this recurrent background.

A fluctuation may create a manifest pair, a latent opposition, a vacancy pair, or a short wrapped cycle.

Most may disappear without producing persistent descendants.

Some may be amplified by local context.

Near a horizon, the distinction between temporary and persistent departures may change because one branch becomes trapped while another escapes.

This supplies a unified setting for source formation, horizon emission, and relational pair creation.

The background is not nothing.

It is the active generative condition from which localized physical histories become distinguishable.

77. Vacuum Deformation and a Cosmological-Constant-Like Regime

A vacuum-like background may possess its own persistent transition organization even in the absence of localized source assemblies.

Suppose the background continually generates a small, uniform increase in the operational separation between sufficiently distant comoving-like observers. The effect does not point toward a source. It is approximately the same in every large-scale direction and persists when localized objects are removed.

Such behavior differs from ordinary gravity-like deformation.

A localized source produces a regional modification centered on, or historically attributable to, a persistent assembly.

A vacuum deformation belongs to the recurrent background itself.

The genesis ledger may record that long-range signal histories require progressively more intermediate stages, that distant clock exchanges drift systematically, or that the number of reachable contexts grows according to a changing large-scale rule. No repulsive force or expanding space is inserted.

A cosmological-constant-like recognition becomes possible when the background deformation satisfies several conditions.

It must persist without localized sources.

It must appear approximately homogeneous across sufficiently large regions.

It must preserve local physics over smaller scales.

It must influence the histories of widely separated observers in a common manner.

It must arise from the same bounded local update system as all other phenomena.

Several cube-level mechanisms could generate such a regime.

The vacuum may contain a recurrent manifest-to-latent conversion that adds hidden transition stages between distant regions.

Recursive wrapping may continually create new operational depth.

Vacancy production may alter the long-range connectivity of the manifest network while remaining locally balanced.

A background cycle may change the relation between primitive update stages and higher-order clock cycles.

The number of effective addresses may grow through assembly division without requiring expansion into an external container.

The direction of the effect should remain open. A vacuum-like background may increase effective separation, decrease it, oscillate, or approach a stable scale.

A cosmological-constant-like term is therefore not inserted as a number. It is recognized as a persistent source-independent deformation mode of the generated vacuum.

---

78. Dark-Matter-Like Behavior From Concealed Source Organization

A region may produce gravitational deformation without containing a correspondingly visible manifest assembly.

The cube ontology already permits latent cubes to influence future outcomes without possessing independently readable manifest states. It also permits hidden interiors, distributed latency, historical vacancies, and relational structures whose effects are inferred indirectly.

These features create a natural route toward dark-matter-like behavior.

Suppose standardized probes and clocks reconstruct a source-conditioned deformation in a region. The deformation behaves like the field of a persistent source: paths converge, signal records change, and nearby assemblies acquire common free histories.

Yet direct manifest probes reveal insufficient visible organization to account for the effect under the source relation previously discovered elsewhere.

Several explanations must be tested.

The missing source may be concealed inside wrapped assemblies.

It may consist of latent cubes.

It may be distributed across relational records rather than localized manifest objects.

It may be a long-lived vacancy structure.

It may be a residual deformation left by a source that is no longer manifest.

It may indicate that the inferred source–geometry law is incomplete.

The phrase “dark matter” should be withheld until ordinary hidden manifest explanations have been excluded and the invisible source behaves as a stable physical population rather than as a correction to the recognition model.

A dark-matter-like cube structure should possess its own persistence, formation pathways, interactions, transfer rules, and contribution to gravitational deformation.

It may interact weakly with ordinary manifest probes while remaining strongly coupled to continuation geometry.

This behavior could arise if the structure occupies an interface inaccessible to common reading apertures but still participates in the local update rules that determine propagation.

The dark source would then be hidden epistemically, not absent ontologically.

A stronger possibility is that the apparent source exists only as distributed latency. No individual hidden cube carries it. The gravitational effect belongs to a relation among many regions.

In that case, the mature language of localized matter may itself be an imperfect compression.

The cube program must permit that outcome.

---

79. Dark-Energy-Like Behavior From Background Historical Load

A source-independent large-scale deformation might also result from historical load stored throughout the vacuum.

The background may contain no visible objects but still require continual local work to preserve its recurrent organization. Latent cycles, vacancy repair, interface balancing, and branch resolution may occur everywhere.

This distributed maintenance burden may alter the relation among distant histories.

Unlike localized matter-like load, it has no compact center.

Unlike ordinary radiation-like propagation, it does not merely pass through the region.

It is a property of the background’s continued existence.

The earlier paper proposes that fields may be stored in background history and that a region can retain altered transition conditions after a localized disturbance has departed. The present

extension asks whether a globally persistent version of that background memory could generate cosmological deformation.

Several cases should be distinguished.

A constant background burden may generate a stable deformation rate.

An accumulating burden may produce accelerating separation.

A decaying burden may produce a transient expansion-like epoch.

A burden coupled to structure formation may vary between regions.

A relational burden stored in long-range latent connections may change when those connections reorganize.

The system should not identify every unexplained expansion-like effect with a new substance. It may instead reflect the dynamics of the vacuum's own history-bearing substrate.

A dark-energy-like recognition becomes justified only after the background effect is shown to be independent of ordinary localized source populations and reproducible across large observer networks.

The mature interpretation may then take one of several forms:

a vacuum source;

a background geometric mode;

a distributed latent field;

a global wrapping process;

a persistent imbalance between manifest presence and structured absence.

The cube framework does not prejudge which description is fundamental.

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80. Matter Formation From Persistent Vacuum Defects

Localized matter-like objects may emerge from defects in the recurrent vacuum background.

A temporary vacancy, latent cycle, orientation mismatch, or interface discontinuity may normally disappear through local repair. Under certain conditions, however, the defect may become self-maintaining.

It may propagate while preserving a signature.

It may recruit neighboring cubes into a stable boundary.

It may cycle through manifest and latent stages.

It may survive encounters and reconstruct itself after damage.

It may carry an opposition or orientation signature.

At that point, the defect has become a candidate particle-like history.

The source paper already identifies persistent localized histories, moving vacancies, defect dynamics, and reconstructive persistence as possible operational ancestors of physical entities.

The gravitational extension adds a further test.

Does the defect modify surrounding continuation structure?

If so, its matter-like and gravitational properties may emerge together.

The object's inertial resistance derives from the organization required to preserve its history.

Its gravitational sourcehood derives from the regional transition burden imposed by that preservation.

Its internal phase derives from latent cycles.

Its charge-like behavior derives from opposition or imbalance.

Its spatial identity derives from the moving boundary of the persistent history rather than from permanent ownership of particular cubes.

Matter is therefore not a substance added to the cube world.

It is a stable mode of vacuum organization.

This interpretation provides a common ancestry for particles and gravitational sources. A matter-like object is a persistent defect; a gravitational source is the deformation created by the continued maintenance of that defect.

The equivalence of inertial and gravitational behavior may then arise because both are manifestations of one persistence organization viewed from different interfaces.

---

81. Antimatter-Like Histories and Gravitational Response

The cube framework permits operational opposition without assigning positive and negative numerical labels in advance.

Two histories may be opposed when they cancel to restore a recurrent template, reverse one another's displacement, or carry complementary latent-cycle stages. Structured vacancies and extra occupancy may likewise form opposed deviations relative to a common assembly.

These mechanisms can generate antimatter-like candidates.

Let P be a persistent localized history and $\bar{P}$ an independently generated opposed history. When brought together under defined conditions, they may:

restore the vacuum background;

produce propagating disturbance histories;

convert manifest organization into latent cycles;

release vacancy and occupancy pairs;

preserve a balance invariant while eliminating both localized objects.

The recognition ledger may later describe the encounter as annihilation-like.

The gravitational question is whether P and $\bar{P}$ produce the same or opposite continuation deformation.

Several outcomes are possible.

Both may generate the same gravitational source signature because historical load depends on persistence rather than on opposition class.

They may generate opposite deformations because sourcehood tracks the imbalance signature.

They may share one universal gravitational component while possessing opposite additional field-like components.

The cube program must not assume the answer.

A result in which opposed matter-like histories fall alike would indicate that gravitational response is tied to common persistence organization rather than to their canceling internal signature.

A result in which they respond differently would reveal a more complicated source structure.

Black holes formed from opposed histories provide a further test. If their exterior gravitational signatures become identical after horizon formation while another conserved boundary signature remains opposite, the horizon has compressed internal distinction without erasing every invariant.

The experiment would clarify which properties gravitation recognizes and which it ignores.

---

82. The Formation of Composite Bodies

Most macroscopic gravitational sources will not be primitive defects. They will be assemblies of many persistent histories.

Recursive wrapping allows such assemblies to become new operational units while preserving their complete internal construction.

A composite body may contain:

many matter-like defects;

balanced opposition pairs;

internal clock networks;

latent binding relations;

moving vacancies;

repair mechanisms;

several nested wrapping levels.

Its exterior gravitational deformation may depend on the complete microscopic arrangement or only on a small coarse signature.

The system should compare composites with identical constituent counts but different internal organizations.

One arrangement may be loosely bound.

Another may contain intense internal cycling.

A third may conceal substantial latent structure.

A fourth may consist largely of balanced pairs whose non-gravitational signatures cancel.

If all produce the same source deformation whenever one coarse historical-load signature agrees, gravitational sourcehood has become insensitive to microscopic composition.

If they differ, internal organization contributes independently.

The difference between the sum of constituent source signatures and the source signature of the bound composite is especially important.

Binding may reduce the exterior load because internal continuation burdens cancel.

It may increase the load because maintaining the composite creates new relational structure.

It may transfer part of the signature into emitted histories during assembly.

A mass-defect-like recognition becomes possible when the composite's source signature differs reproducibly from the sum of isolated constituents and the difference is accounted for by binding history.

The familiar claim that binding contributes to mass-like behavior must be earned from the cube ledger through source deformation, inertial response, and conservation tests.

---

83. Gravitational Screening and Anti-Screening

The regional deformation generated by several sources may combine in different ways.

Two nearby source assemblies may produce a deformation approximately equal to the combined effect measured from each in isolation.

Their effects may partially cancel.

They may amplify one another.

One source may conceal the effect of another from distant probes.

The combined region may reorganize into a new source class not predictable through simple addition.

The cube program should therefore test superposition rather than assume it.

At weak historical load, local modifications may rarely interfere, producing an approximately additive field-like regime.

At stronger load, the same local contexts may be claimed by several source histories, creating nonlinear interaction.

Screening-like behavior occurs when a composite source produces less distant deformation than expected from its separated components.

This may happen because:

opposed interface burdens cancel;

latent structures close internally;

vacancy polarization remains confined;

wrapping hides internal transition activity;

the exterior boundary exposes only a neutral residual signature.

Anti-screening-like behavior occurs when the combined assembly produces greater deformation than expected.

This may result from:

new recursive maintenance requirements;

coherent alignment of latent cycles;

branch funneling across a larger region;

formation of a shared horizon;

amplification of background historical load.

The resulting source law may be linear only in a restricted regime.

A black-hole transition is likely to be strongly nonlinear because the formation of a horizon changes the topology of accessible future histories.

The system should map these regimes rather than fit one universal approximation across them.

---

84. The Principle of Gravitational Universality

A mature cube gravitation theory requires a clear statement of what is universal.

Not every effect surrounding a source must be universal. Charge-like, orientation-sensitive, or label-specific interactions may coexist with gravity-like deformation.

The gravitational component is the part of the source-conditioned continuation structure shared by all sufficiently passive persistent probes.

A passive probe is one whose presence does not significantly reorganize the source or surrounding region during the measurement.

Different passive probes may possess different internal cycles, constituent cubes, opposition classes, orientations, and wrapping histories.

If their free histories can all be predicted by one common effective geometry, the deformation is universal over that probe class.

Universality may be limited.

Primitive probes may reveal substrate anisotropy.

Large wrapped probes may average over it.

Strongly interacting probes may deviate from the common paths.

Latent-only probes may reconstruct a different effective structure.

The recognition ledger should therefore state the domain of gravitational universality explicitly.

The strongest possible result would show that every persistent localized history, regardless of internal construction, responds to source-conditioned geometry through the same operational rule once direct interactions are removed.

A weaker but still meaningful result would establish universality only within one emergent matter sector.

The cube world may contain several sectors that experience different geometries. Such a world would not reproduce one universal spacetime, but it could remain internally coherent.

The search should not discard such worlds merely because they differ from expectation.

Nevertheless, the emergence of one broadly universal continuation geometry would be a major compression achievement. It would allow a vast diversity of cube assemblies to inhabit one shared physical world.

---

85. A Hierarchy of Geometries

The generated world may possess more than one geometry-like description.

The manifest cube network defines one accessibility structure.

Latent mediation defines another.

Vacancy passages define a third.

Relational bridges define a fourth.

Recursive wrapping creates higher-level effective neighborhoods.

Different probe families may interact primarily with different layers.

Ordinary matter-like histories may reconstruct one metric-like structure.

Latent cycles may accumulate according to another.

Bridge-internal histories may inhabit a concealed geometry invisible to manifest probes.

A horizon may mark the point at which one geometry ceases to provide outward continuation while another hidden geometry continues.

The mature theory may therefore require a hierarchy rather than one universal geometric object.

This is not automatically a failure of unification. Several apparent geometries may be projections of one deeper admissible-history structure.

The system should search for translation relations among them.

A manifest path may correspond to a longer latent path.

A short relational bridge may correspond to a large exterior separation.

A vacancy tunnel may alter manifest connectivity without changing latent correlation.

A wrapped address may compress many primitive steps into one effective transition.

The hierarchy may be represented as:

primitive contact geometry;

propagation geometry;

clock geometry;

source-conditioned gravitational geometry;

latent relational geometry;

wrapped bridge geometry.

A unified recognition becomes possible when these levels are derived systematically from one genesis ledger and their domains of validity are known.

The goal is not necessarily to collapse them into one picture.

It is to explain why different observers and probes reconstruct different but compatible geometrical compressions of the same cube histories.

---

86. The Emergence of Local Frames

A generated observer requires a way to define its immediate orientation, clock, and neighborhood without consulting the external implementation coordinates.

A local frame may be constructed from a stable assembly of reference histories.

One recurrent process supplies a clock-like direction through ordered stages.

Several transported interface patterns supply spatial-like orientation distinctions.

Standardized local probes establish which nearby continuations count as reference-free motion.

The observer then describes incoming histories relative to this internally maintained apparatus.

A source-conditioned region may alter the frame's relation to distant frames while leaving local internal laws approximately unchanged.

Transporting the frame around a closed path may produce a residual orientation or clock shift.

Crossing a horizon may preserve the frame locally while eliminating future outward communication.

Passing through a traversable bridge may relate the frame to a distant exterior in a new way.

The cube system should test whether local frames can be constructed entirely from generated objects and whether their translations obey stable rules.

No external "up," "left," global time, or fixed lattice orientation should remain detectable within the mature regime.

The original cube requires a permanent orientation convention for reproducibility, but that convention belongs to the genesis apparatus. Physical orientation must instead be reconstructed from relations among transported histories.

This distinction is essential.

A world may use a cubic substrate while its observers discover no privileged cubic frame.

That would demonstrate that the substrate has generated rather than merely displayed geometry.

---

87. Geodesic-Like Histories as Self-Preserving Continuations

A freely moving persistent assembly follows the continuation sequence that best preserves its operational identity in the surrounding region.

No rule instructs it to choose the shortest path.

No external optimizer directs it toward a destination.

At each local stage, its repair, boundary, phase, and propagation mechanisms select among available continuations.

In a reference region, this may produce approximately straight recurrent transport.

In a source-conditioned region, the same local self-preservation rules produce a curved effective path because the continuation structure has changed.

The assembly is not forced away from its natural history.

Its natural history has been redefined by the region.

A geodesic-like recognition becomes appropriate when:

diverse free probes follow the same effective path family;

the paths are determined locally from the regional continuation structure;

direct object-specific forces are absent;

small deviations tend to evolve according to common neighboring-path behavior;

the same structure predicts clocks and closed transport.

This construction explains why gravitational motion can appear force-free at the mature level while remaining the product of local cube interactions underneath.

The path is geodesic-like because it is the most self-preserving admissible continuation in the effective geometry.

Whether this path minimizes, maximizes, or stationarizes an action-like record remains an empirical question.

---

88. Tidal-Like Behavior

A sufficiently small observer may fail to distinguish free gravitational history from acceleration-like transformation. A larger assembly may detect differences across its extent.

Two nearby probe histories released with matching local states may converge, diverge, rotate, or distort relative to one another as they pass through a source-conditioned region.

The effect cannot be eliminated by redefining the motion of one local frame because it concerns relations among neighboring free histories.

This provides the anonymous ancestor of tidal behavior.

The genesis ledger records:

initially matched separation signatures;

subsequent changes in relative contact accessibility;

clock differences across the extended assembly;

differential path curvature;

internal stress, repair, or deformation required to keep the assembly intact.

A tidal-like recognition becomes justified when these relative effects are predicted by the same continuation-curvature structure that governs closed transport and probe deflection.

Strong tidal organization may destroy composite probes before they reach a horizon.

In other source configurations, a large horizon may form where local tidal differences remain weak over the scale of an infalling observer.

The cube program can therefore distinguish horizon formation from local destructive force.

The horizon is defined globally by escape accessibility.

Tidal behavior is defined locally by differential continuation.

Their magnitudes need not coincide.

This distinction will be important when classifying different black-hole candidates.

---

89. Black-Hole Species

The cube world may generate several operationally distinct classes of black holes.

A **terminal black hole** contains interior histories that end in contexts with no permitted continuation.

A **cyclic black hole** contains a finite recurrent interior.

A **recursive black hole** generates ever-deeper wrapped structures.

A **branching black hole** contains continuing unresolved or persistent future branches.

A **latent black hole** converts most entering manifest history into concealed transformation structure.

A **vacancy black hole** is organized around a self-maintaining structured absence.

A **bridge black hole** exposes one endpoint of a relational interior shared with another horizon.

A **radiative black hole** slowly releases source signature through horizon reorganization.

A **remnant black hole** approaches a stable minimum horizon state.

These classes may share the same coarse trapping definition while differing internally and in their long-term behavior.

The recognition ledger should not collapse them prematurely into one familiar name.

The classification must be based on operational probes, accretion response, emission, horizon dynamics, and relational tests.

Some classes may converge at large scales. Others may remain physically distinguishable.

The existence of multiple black-hole species would demonstrate generative surplus beyond a direct reproduction of one classical solution family.

---

90. The Central Ontogenetic Conjecture

The complete proposal can now be stated in its strongest form.

A finite world of labeled cubes, local encounters, ordered histories, latent transformations, structured absences, and recursive wrapping may generate a hierarchy of structures whose mature descriptions include matter, fields, clocks, causal order, gravitation, horizons, black holes, EPR-like relations, and bridge geometries.

None of these mature categories is primitive.

They arise through successive compression of provenance-complete histories.

Matter is persistent localized organization.

A field is a distributed modification of possible transition.

Time is comparative recurrence among histories.

Space is stable accessibility among event contexts.

Gravity is source-dependent deformation of shared continuation geometry.

A horizon is a boundary beyond which no admissible manifest continuation reaches an exterior domain.

A black hole is a self-maintaining source whose deformation generates such a boundary and conceals a continuing interior.

An EPR-like pair is a separated manifest interface to one nonfactorizable relational history.

An EPR bridge is the higher-order concealed assembly through which that relational history acquires an interior-like structure.

The ultimate generative chain is:

distinguishable marks
→ cubes
→ encounters
→ histories
→ persistence
→ relational dependence
→ effective objects
→ propagation and clocks
→ effective geometry
→ source deformation
→ horizons
→ black holes
→ paired latent interiors
→ EPR bridges

The conjecture remains unproved.

The paper has defined a research program, recognition criteria, false-positive controls, computational architecture, and a series of operational thresholds.

The next requirement is implementation.

The value of the proposal will depend not on the suggestiveness of its language but on whether a bounded anonymous update engine actually produces the required histories without having their mature physical meanings inserted into its rules.

91. A Minimal Anonymous Rule Family

The first implementation should not attempt to reproduce the full labeled-cube universe. It should preserve the ontology while reducing the active rule space to a tractable experimental core.

Let every address possess one of three occupancy modes:

manifest;

latent;

missing.

A manifest cube carries a restricted panel, seam, and junction record. A latent cube carries a transition record unavailable to ordinary manifest probes. A missing address carries a vacancy history rather than a blank label.

Each local update reads only:

the focal address;

its directly contacted neighbors;

the occupancy mode of those neighbors;

a bounded segment of local history;

any latent record attached to the focal interfaces.

The update may perform only anonymous actions:

retain a mark;

replace a mark;

exchange two marks;

reorient a cube;

create or remove a contact;

convert manifest presence into latency;

convert latency into manifestation;

create or fill a vacancy;

promote a recurrent local history;

wrap a stable assembly.

No rule may inspect global source strength, distance from a selected object, total density, shortest path, curvature, or horizon membership.

A useful initial family could be built from four neutral mechanisms.

The first mechanism rewards interface compatibility. Compatible neighboring histories preserve their current contacts with few intermediate updates.

The second mechanism requires incompatible but persistent interfaces to pass through latent mediating stages before a stable continuation becomes available.

The third mechanism allows recurrent assemblies to modify adjacent interface records as part of their own maintenance.

The fourth mechanism moves or repairs vacancies according to local compatibility rather than according to global direction.

These rules contain no gravity. They merely allow persistence to alter the cost and availability of neighboring continuation.

The central experimental question is whether a persistent assembly creates an outwardly propagating region in which unrelated probes acquire common path, delay, clock, and transport effects.

If so, the first anonymous source-conditioned geometry has appeared.

---

92. The Reference World

Every gravitational claim requires a reference world.

The reference should not be assumed to be empty. A completely empty address region contains no clocks, probes, contact structure, or propagation medium. The more useful reference is a dynamically stable vacuum-like background.

The background should satisfy:

bounded local updates;

persistent propagation capacity;

approximately uniform clock comparison;

no dominant localized source;

repair of small disturbances;

stable large-scale probe behavior;

no preferred center within the tested region.

Several candidate backgrounds may be generated. The system should not manually select the one that most closely resembles familiar space. It should retain each sufficiently stable regime and investigate its physical fertility.

For every candidate vacuum, the program constructs a reference atlas.

The atlas records:

all stable localized probe families;

their propagation signatures;

their limiting propagation depths;

their internal clock cycles;

their closed-transport behavior;

their interaction cross-signatures;

their response to orientation changes;

their behavior under recursive wrapping.

Only after this atlas exists can a source-induced deviation be measured.

The reference is therefore not metaphysically absolute. It is a recurrent operational state against which departures become reproducible.

Different vacuum regimes may generate different gravities.

A source-like assembly may deform one background but dissolve in another.

A black-hole transition may occur in one rule phase but be impossible in another.

An EPR-like relational structure may survive only in vacua that support long-lived latency.

The project should therefore describe gravity as relative to a generated world phase, not as a universal property of cubes considered in isolation.

---

93. Source Construction Protocol

A source candidate should be constructed through the same rules as every other object.

The program begins with spontaneous or seeded local disturbances in the reference vacuum. Candidate assemblies are retained when they satisfy predefined neutral persistence tests.

A qualifying assembly must:

survive for a minimum history depth;

retain a recognizable boundary or operational signature;

recover from at least one class of local disturbance;

interact nontrivially with probes;

remain localized or coherently propagating;

possess complete replayable provenance.

No requirement of gravitational behavior enters this selection.

The qualifying assembly is then placed into several copies of the reference world under different orientations and locations. The surrounding background is allowed to relax under ordinary local updates.

Probe and clock families are released only after the source-conditioned region reaches a recurrent or statistically stable state.

This separation distinguishes the immediate collision effects of source insertion from the persistent environmental effect of source maintenance.

A source candidate is promoted when the surrounding modification:

extends beyond direct contact;

propagates outward through finite stages;

persists while the source persists;

changes when the source changes;

decays or reorganizes when the source is removed;

affects several passive probe families.

The source should then be varied systematically.

Its constituent count may change.

Its internal cycle depth may change.

Its latent content may change.

Its wrapping depth may change.

Its vacancy organization may change.

Its boundary complexity may change.

The purpose is to determine which features predict the surrounding deformation.

The resulting source signature must be discovered through comparison, not selected beforehand.

---

94. Measuring Effective Distance

A primitive distance-like record can be constructed without coordinates.

For two operational contexts A and B, define a standardized signal family S. Release S from A and record every successful history by which a recognizable descendant reaches B.

The system stores:

the minimum update depth;

the distribution of successful depths;

the number of admissible path families;

the latent mediation required;

the damage or reconstruction needed;

the clock cycles accumulated by the signal;

the return history from B to A.

No one of these records is initially “the distance.”

A distance-like description is earned when a compact quantity or ordered signature predicts most of them across many context pairs.

The same procedure is repeated with several signal families.

If different signals produce incompatible separation orderings, the world has no probe-independent metric-like structure at that scale.

If their orderings agree approximately, a common operational geometry is emerging.

A source deformation is then measured by comparing the separation records before and after source insertion.

The source may increase minimum propagation depth.

It may reduce the number of admissible outward paths.

It may create asymmetry between outward and return histories.

It may introduce path-dependent latent cycles.

It may make some previously reachable contexts inaccessible.

This measurement architecture avoids treating visual cube spacing as physical distance.

---

95. Measuring Effective Curvature

Four independent tests should be used.

The first is **path convergence**. Initially parallel-like probe histories are released through the region. Their later operational separation is recorded.

The second is **clock divergence**. Equivalent clocks follow different histories and are later compared.

The third is **closed transport**. A stable assembly returns to its starting context after following a loop, and its final operational state is compared with its initial state.

The fourth is **continuation noncommutation**. Two local transport procedures are applied in opposite orders. If they reach equivalent manifest addresses but produce different transported states, the region contains an order-dependent residual.

A curvature-like signature is strong when all four tests are predicted by one common regional model.

A path may curve because of probe-specific scattering.

A clock may change because of direct source interaction.

A transport residual may arise from local anisotropy.

A shared effective curvature becomes plausible only when these effects cohere.

The cube world should therefore reject single-observation curvature claims.

Curvature is not a picture of a bent lattice.

It is a common compression of several history-dependent failures of flat reference behavior.

---

96. Detecting a Horizon

Finite simulation cannot establish nonescape merely by waiting.

A horizon certificate requires structural analysis of the local continuation rules.

The reachability engine begins with a candidate interior context. It generates all permitted future branches while merging only those states proven operationally equivalent under the active probe set.

For every generated state, it asks whether an exterior reference domain has been reached with a recognizable transferable signature.

If escape occurs, the context is not trapped.

If no escape occurs within a finite depth, the result remains unresolved.

Certification requires discovering a closed continuation class K with the following properties:

every state in K has successors only in K, in terminal states, or in latent states whose later manifestations also return to K;

no state in K has a permitted transition to the exterior domain;

the candidate interior enters K under all admissible continuations;

the closure statement is replayable and independently verifiable.

K is the anonymous trapped set.

Its boundary consists of local contexts for which one class of continuations enters K while another remains exteriorly accessible, or for which a small context change switches the accessibility class.

A horizon is recognized only when this boundary is generated dynamically by the source-conditioned update structure.

The certificate may first exist only for a finite reduced state model. Larger simulations can test whether the same trapping organization persists under added context and finer probe resolution.

---

97. Detecting EPR-Like Nonfactorization

The relational experiment requires several probe choices at each endpoint.

Let A possess probe contexts a_1, a_2, and possibly additional alternatives. Let B possess b_1, b_2, and so forth.

For every ordered probe pairing, the program records the complete family of joint outcomes and the locally visible outcome families.

The first test asks whether one independent endpoint record can be assigned to A and one to B such that the joint outcomes follow solely from those local records and the selected local probes.

The test must include hidden local registers generated at the pair's common origin. Otherwise, ordinary shared-history correlations may be falsely classified as nonfactorizable.

If a complete local decomposition exists, the pair remains classically separable under the tested probes.

If none exists, the program enlarges the local context. It includes longer endpoint histories, hidden interior states, and nearby environmental records.

Only after every permitted endpoint-local enlargement fails should a relational latent object be considered necessary.

The second test checks no-signaling-like behavior. For each B-local probe, the locally readable B outcome family must remain unchanged under alternative A-side probe choices when the A record is withheld.

The third test checks relational persistence. The joint constraint must survive endpoint separation and ordinary local disturbances that do not destroy the shared history.

The fourth test checks provenance. The relation must arise from a finite local construction rather than from an external global coordinator.

An EPR-like recognition is therefore the conjunction of:

nonfactorization;

context dependence;

local no-signaling;

persistent shared provenance.

---

98. Detecting a Bridge

Once an EPR-like pair is found, the system searches for a compact concealed assembly reproducing its complete joint behavior.

The search may use recursive promotion.

Repeated joint histories are encoded as relational records.

Equivalent relational subhistories are compressed.

Stable sequences of relational transformations become latent cells.

Groups of latent cells are wrapped into higher-order assemblies.

The resulting object is inspected for two exposed interfaces corresponding to A and B.

A bridge candidate exists when the minimum sufficient relational model is not merely a lookup table but possesses internal continuation structure.

The system should determine whether the interior supports:

ordered stages;

alternative paths;

recurrent cycles;

transportable latent signatures;

internal defects;

clock-like processes;

closed-history residuals;

boundary-dependent accessibility.

If these are absent, the object is a joint constraint but not yet a geometry-like bridge.

If they are present, internal signal and clock experiments may be defined at the relational level.

The bridge becomes spatially recognizable when its internal histories support the same kinds of operational compression used to reconstruct the exterior geometry.

A paired black-hole bridge requires the further condition that A and B each act as horizon interfaces between their exterior domains and the concealed assembly.

---

99. A Candidate Discovery Ledger

Every proposed discovery should be stored in a standardized record.

A gravity-candidate entry should include:

the rule identifier;

vacuum identifier;

source construction tree;

source persistence certificate;

probe families;

reference histories;

source-conditioned histories;

clock comparisons;

transport residuals;

universality tests;

failed probes;

coordinate re-encodings;

recognition confidence.

A black-hole-candidate entry should additionally include:

the trapped-state class;

horizon certificate;

interior continuation record;

accretion histories;

emission histories;

invariant transfers;

horizon perturbation tests;

observer accessibility classes.

An EPR-pair entry should include:

the common-origin history;

endpoint construction records;

probe settings;

joint branch records;

local branch records;

factorization attempts;

no-signaling tests;

relational latent representation;

disturbance and persistence tests.

A bridge entry should additionally include:

the concealed assembly;

endpoint-interface map;

internal continuation graph;

internal clock and transport tests;

traversability status;

causal-cycle tests;

paired-horizon relation;

alternative recognition translations.

Negative entries are equally important.

A failed candidate should state exactly which threshold was not met.

This prevents suggestive partial behavior from being repeatedly rediscovered and overstated.

---

100. Independent Verification

The discovery engine and verifier should not share the same recognition code.

The discovery engine may identify promising histories through heuristics, compression scores, and approximate measurements.

The verifier receives only:

the primitive rule;

the initial world state;

the claimed construction sequence;

the claimed probe protocols;

the claimed operational threshold.

It independently replays the world and checks the claim from the genesis ledger.

For gravity, it verifies source persistence, bounded propagation, multi-probe deformation, clock comparison, and coordinate independence.

For black holes, it verifies the trapping certificate and tests whether the boundary is source-generated rather than fixed.

For EPR-like pairs, it verifies all joint records, factorization failures, and local no-signaling conditions.

For bridges, it reconstructs the concealed assembly and checks that both mature interpretations refer to the same anonymous object.

The verifier must fail closed whenever:

a branch was omitted;

a latent state lacks provenance;

an equivalence merge is unjustified;

a global rule was disguised as local;

a horizon is inferred only from finite waiting;

a correlation test excludes a valid local hidden record;

a bridge geometry predicts behavior absent from the relational ledger.

The source framework treats provenance completeness and fail-closed verification as essential protections against semantic leakage and unsupported compression. The gravitational program cannot be credible without the same discipline.

---

101. Expected Early Results

The first implementation is unlikely to generate a complete gravitational world.

More probable early discoveries include:

probe-specific deflection around persistent assemblies;

source-induced propagation delay;

history-dependent interface fields;

clock changes tied to latent mediation;

moving vacancy structures behaving as defect particles;

partial trapping regions;

one-way interfaces;

classically correlated relational pairs;

nontraversable wrapped connections;

scale-dependent effective geometry.

These partial structures should not be dismissed.

They define the developmental path toward stronger physics.

A world may produce universal path deformation but no clock effect.

Another may produce clock deformation but no equivalence-like behavior.

Another may generate robust horizons through branch funneling while failing to support a smooth exterior geometry.

Another may generate contextual endpoint correlations without any bridge-like interior.

The project's value lies partly in mapping these dependencies.

It may reveal that certain mature physical concepts require distinct primitive mechanisms.

It may instead reveal that one compact mechanism generates several of them together.

Both outcomes advance the ontogenetic program.

---

102. Strong Predictions of the Framework

Although the theory remains speculative, its architecture yields several testable expectations about successful cube worlds.

First, gravity-like behavior should correlate more strongly with persistence burden than with raw cube count.

Second, effective curvature should be reconstructible from at least two independent classes of experiments, such as propagation and closed transport.

Third, horizon formation should appear as a qualitative transition in continuation reachability rather than as gradual darkening alone.

Fourth, black-hole interiors should exhibit several possible genesis organizations that collapse into fewer exterior signatures.

Fifth, EPR-like relations should be representable as provenance-bearing relational objects rather than as instantaneous endpoint modification.

Sixth, bridge geometry should appear only after relational structure develops internal operational depth.

Seventh, a nontraversable bridge should be easier to generate than a traversable one because constraint requires less structure than controlled transport.

Eighth, effective smoothness and isotropy should improve under recursive wrapping and coarse observation.

Ninth, the geometric description should fail near sufficiently fine, strongly branching, or deeply latent regimes.

Tenth, gravity-like and EPR-like behavior should cluster in rule families that preserve history across manifest, latent, and relational forms.

These predictions concern the cube research program itself. They are not claims about empirical nature unless and until a generated world achieves sufficiently strong correspondence with observation.

---

103. What Would Count as Success

The weakest success would be a reproducible cube world in which persistent assemblies create multi-probe continuation deformation through bounded local rules.

A stronger success would add universal clock effects and closed-transport residuals supporting one effective geometry.

A still stronger success would generate source scaling, conservation-like transfer, equivalence-like free motion, and propagating geometry disturbances.

Black-hole success would require a dynamically formed, certified trapping boundary with continuing concealed interior history.

Quantum-relational success would require contextual, nonfactorizable, no-signaling-like endpoint constraints generated through local provenance.

Bridge success would require that the same relational object acquire an internally structured concealed geometry with two horizon interfaces.

The strongest success would be a single compact anonymous rule family generating all of these structures while supporting independent replay and recognition translations.

That would not by itself prove that physical reality is made of cubes.

It would demonstrate something more limited but still important:

a remarkably small history-bearing substrate can regenerate a broad architecture of gravitation and quantum relationality without receiving those theories as primitives.

Such a result would establish the cube world as a constructive model of physical ontogenesis.

---

104. What Would Count as Failure

The program fails in its strongest ambition if gravitational behavior appears only after source-directed rules are inserted.

It fails if effective geometry remains tied to the visual implementation lattice and cannot be reconstructed by embedded clocks and probes.

It fails if black holes reduce to deletion zones or material boxes.

It fails if EPR-like behavior requires global coordination or permits controllable instantaneous signaling.

It fails if bridge structure is merely drawn rather than operationally generated.

It fails if recognition labels are used to prune the search before anonymous criteria are applied.

It fails if the complete history cannot be replayed independently.

It fails if negative cases and alternative branches are omitted.

A partial failure may still yield useful mathematics or physics. The substrate may generate novel defect dynamics, causal networks, observer-relative clocks, or relational topologies even if it does not reproduce gravitation.

The project should therefore distinguish failure of a specific recognition from failure of the generative program as a whole.

The cube world need not become our physics to reveal how formal and physical structure can emerge from anonymous finite histories.

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105. Conclusion

The two preceding cube papers establish a methodological and ontological foundation. The first begins with anonymous labeled cells, local encounter, recursive wrapping, complete provenance, delayed recognition, and the principle that mathematical meaning must be earned after construction. The second adds ordered histories, locality, limited propagation, persistent processes, internal clocks, latent cubes, missing cubes, distributed transition conditions, defects, fields, observers, and curvature-like behavior.

The present paper extends that foundation toward gravitation.

Gravity is proposed to emerge when a persistent cube history systematically reorganizes the admissible continuations of surrounding histories. The deformation becomes geometry-like when diverse probes and clocks reconstruct one common regional structure.

A black hole emerges when the deformation becomes self-trapping. Its horizon is not a material shell but a boundary in continuation space: outside it, outward histories remain possible; inside it, no admissible manifest history reaches the exterior.

An EPR-like pair emerges when two separated manifest assemblies remain interfaces of one nonfactorizable relational history. The relation originates locally, persists through separation, constrains joint outcomes, and does not permit ordinary controllable signaling.

An EPR bridge emerges when this relational history is promoted and wrapped into a concealed assembly with two interfaces and sufficient internal organization to support geometry-like description. When both interfaces become horizon-like boundaries, one anonymous construction may support both EPR-like and Einstein–Rosen-like recognition.

The deepest proposal is therefore not that cubes imitate curved spacetime.

It is that spacetime, gravity, horizons, and bridges may be late descriptions of something more primitive:

provenance-organized admissible history.

Cubes provide finite carriers of that history.

Latency preserves what is operative but not manifest.

Absence constrains what can continue.

Wrapping creates new scales of object and interior.

Persistence creates sourcehood.

Limited propagation creates causality.

Common deformation creates geometry.

Self-trapping creates black holes.

Nonfactorizable shared history creates EPR structure.

Concealed relational continuity creates bridges.

The theory remains a program rather than a completed derivation. Its next stage is computational and falsifiable: construct the smallest anonymous local rule family capable of generating persistence, universal continuation deformation, certified horizons, and relationally constrained paired interiors without using the mature names or equations of the physics it seeks to recover.

The guiding rule remains unchanged:

Generate first, recognize second, and name last.

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Appendix A. Neutral Genesis Vocabulary

The purpose of this appendix is to define the restricted vocabulary of the gravitational genesis ledger. These terms identify reproducible operations and records. They do not assert that the generated structures already possess familiar mathematical or physical meanings.

A.1 Address

An address is a reproducible identifier for a possible site of occupancy, contact, or update. An address belongs to the implementation ledger. It is not initially a point in physical space.

Two addresses may be adjacent under the implementation rules without being operationally close under generated propagation. Conversely, two manifestly nonadjacent addresses may possess a short latent or wrapped relation.

A.2 Address Class

An address class is a collection of addresses indistinguishable under a specified family of local operations or probes.

An address class may later be recognized as a region, orbit, equivalence class, coordinate neighborhood, or another familiar structure. No such interpretation is primitive.

A.3 Admissible Continuation

An admissible continuation is a next recorded state permitted by the active local rule, current bounded context, and relevant history.

A context may possess one continuation, several continuations, or none.

The complete admissible-continuation structure includes unrealized branches as well as the realized history. Horizons and EPR-like relations depend on this broader structure and cannot be inferred from one realized path alone.

A.4 Assembly

An assembly is a finite collection of cubes, latent records, vacancies, contacts, and interfaces joined through a replayable construction history.

An assembly becomes persistent when some defining operational organization survives across updates. It may later be wrapped and treated as one higher-order cube.

A.5 Boundary Context

A boundary context is a local configuration at which two classes of continuation meet.

A trapping boundary, for example, separates contexts possessing an outward continuation from contexts possessing none. The boundary need not coincide with a permanent shell of manifest cubes.

A.6 Branch

A branch is one permitted continuation among several arising from the same recorded context.

Branches remain distinct until an explicit probe or verified compression establishes operational indistinguishability. The ledger never discards a branch merely because it conflicts with an expected physical interpretation.

A.7 Branch Family

A branch family is a collection of branches grouped under an explicitly stated operational test.

Two families may have identical manifest projections while retaining different latent histories or future responses.

A.8 Branch Funneling

Branch funneling is a local or regional process through which some continuation classes are progressively eliminated or redirected while others remain admissible.

Repeated branch funneling may later be recognized as attraction-like propagation, causal orientation, or horizon formation. Those aliases are not present in the genesis record.

A.9 Causal Closure

A state family K is causally closed relative to an exterior domain E when every successor of every state in K remains in K, becomes terminal, or enters latency whose possible later manifestations also remain in K, and no admissible continuation reaches E.

Causal closure supplies the strongest anonymous certificate of trapping.

A.10 Clock Assembly

A clock assembly is a persistent recurrent history whose distinguishable stages provide reproducible comparison markers.

The global update index is not itself a physical clock. Physical time-like structure appears only when generated assemblies use recurrent histories to compare other histories. The source paper explicitly treats physical time as something earned through persistence, finite propagation, recurrence, and observer comparison rather than assumed from the update index.

A.11 Comparison Record

A comparison record stores the result of bringing two histories, clock assemblies, probe records, or observer memories into one common reading context.

A relational correlation may remain inaccessible until the relevant comparison record is generated through an ordinary permitted history.

A.12 Concealed Assembly

A concealed assembly is an assembly whose complete internal state is unavailable to a specified manifest probe family while its interfaces continue to influence observable outcomes.

Concealment may result from wrapping, latency, causal trapping, limited reading aperture, or a combination of these.

A.13 Contact

A contact is a permitted adjacency between specified interfaces of two cubes or assemblies.

Contact is operational. It does not initially mean force, communication, multiplication, composition, or bonding.

A.14 Continuation Depth

Continuation depth is the number of recorded update stages in a candidate history.

It is a ledger quantity. A duration-like interpretation is justified only after continuation depth is systematically related to generated clock histories.

A.15 Continuation Geometry

Continuation geometry is a recognition-level compression of the admissible paths, delays, clock comparisons, transport residuals, and reachability relations generated within a region.

The genesis ledger contains no geometry object by this name. It contains only the histories from which such a description may later be reconstructed.

A.16 Conversion

A conversion changes the occupancy mode or operational class of a context.

Permitted examples include:

manifest → latent;

latent → manifest;

manifest → missing;

missing → manifest;

latent → missing;

missing → latent.

Every conversion retains a provenance record.

A.17 Cube

A cube is an oriented bounded cell containing addressable panel, seam, and junction sites and, where permitted, an interior register.

The cube is not assumed to be a unit of physical space. It is a structurally fertile carrier of distinguishability, contact, orientation, boundary, concealment, and recursive composition. The source architecture explicitly treats the cube as an experimental seed rather than as an asserted geometric atom of reality.

A.18 Deformation Record

A deformation record compares the history of a standardized probe or clock in a reference world with its history in a modified world.

It may contain path changes, added stages, altered branches, clock divergence, latent activation, vacancy displacement, transport residuals, or loss of reachability.

A.19 Direct Interaction

A direct interaction occurs when a probe's history changes through contact with the source assembly or through a specialized label-sensitive interface.

Direct interaction must be separated from geometry-like deformation, which should be reconstructed commonly by diverse passive probe families without direct source contact.

A.20 Distinguishability

Two histories are distinguishable under probe family P when at least one permitted probe in P produces different readable records.

Distinguishability is always relative to a stated probe family and history depth.

A.21 Effective Exterior

An effective exterior is a connected class of manifest contexts used as the reference domain for escape, signal exchange, or observer access.

The exterior is not simply everything visually outside a drawn boundary. It is defined through manifest reachability.

A.22 Event

An event is the smallest ledger-recorded difference between consecutive stages under the active resolution.

A more refined ledger may later resolve one event into several lower-level events.

A.23 Exterior Signature

An exterior signature is the complete response pattern of a concealed or trapped assembly under a standardized family of probes available from its effective exterior.

Different interiors may share one current exterior signature while retaining distinct provenance.

A.24 Genesis Ledger

The genesis ledger is the authoritative record of primitive marks, addresses, occupancy modes, contacts, local rules, branches, conversions, histories, assemblies, wrappings, probes, failures, and verification results.

It contains no imported names such as mass, curvature, black hole, entanglement, or wormhole. The separation between genesis and recognition is a provenance requirement, not merely a stylistic preference.

A.25 Historical Load

Historical load is a provisional anonymous signature describing how strongly a persistent assembly constrains its own continuation and the continuations available in its surrounding region.

It may depend on recurrence, repair, latent mediation, wrapping depth, vacancy organization, interface maintenance, or other generated features.

Historical load is not automatically mass or energy. It becomes mass-energy-like only if it predicts inertial resistance, universal gravitational deformation, conservation, and transfer.

A.26 History

A history is an ordered provenance-complete record of successive states, intermediate latent stages, branch choices, contacts, conversions, and assembly transformations.

The temporal cube framework treats the history-bearing process, rather than the isolated present state, as the central candidate for physical identity.

A.27 Horizon Candidate

A horizon candidate is a dynamically generated boundary separating contexts that possess at least one outward manifest continuation from contexts possessing none.

The term remains provisional until trapping is structurally certified, robust across probe families, and generated by the same source-conditioned deformation responsible for exterior gravitational behavior.

A.28 Indistinguishability

Two histories are indistinguishable under probe family P when no probe in P distinguishes them through the stated history depth.

Indistinguishability is weaker than identity.

A later enlarged probe family may separate histories previously grouped together.

A.29 Interface

An interface is the part of a cube or assembly exposed to a specified class of contact, reading, or transformation.

Different interfaces may be selected for the same concealed interior. The resulting external behaviors may differ even when the underlying assembly is unchanged.

A.30 Internal Continuation

An internal continuation is a permitted history that remains within a concealed, wrapped, or trapped assembly relative to the selected exterior.

Internal continuation does not imply that an exterior observer can access or reconstruct the history.

A.31 Latent Cube

A latent cube is an operative structure that contributes to future outcomes without possessing an independently readable manifest state under the current probe system.

Latency may belong to one address, one transition interval, one interface, one distributed assembly, or one relation between separated histories. The source paper treats latency as unmanifest transformation capacity rather than merely an ordinary cube whose labels have been covered.

A.32 Latent Mediation

Latent mediation occurs when a manifest transition cannot be reproduced directly but can be reproduced through one or more intervening latent stages.

The number and organization of these stages may later contribute to clock, phase, distance, or action-like recognition.

A.33 Local Rule

A local rule is an update procedure that reads only bounded context and applies a replayable change.

The context may include the focal cube, directly contacted neighbors, nearby vacancies, active latent records, orientation relations, and a bounded history segment.

A local rule may not inspect an unrestricted global field or a precomputed gravitational quantity.

A.34 Manifest Cube

A manifest cube occupies a declared address and exposes readable marks to the ordinary probe system.

Manifest status concerns current accessibility, not permanence or fundamental reality.

A.35 Missing Cube

A missing cube is structured nonoccupancy at an address where occupancy is defined or expected.

It is not a blank-labeled cube. Vacancy history may affect boundaries, propagation, repair, opposition, topology-like organization, and defect dynamics. The source framework explicitly distinguishes active absence from blank presence.

A.36 No-Signaling-Like Condition

A separated relational pair satisfies a no-signaling-like condition when changing the local probe choice at one endpoint does not alter the readable local branch family available at the other endpoint before an ordinary comparison history is completed.

Joint records may nevertheless remain constrained.

A.37 Nonfactorizable History

A joint history is nonfactorizable relative to a tested context when no pair of independently sufficient endpoint records reproduces the complete family of joint outcomes.

Before declaring nonfactorization, the context ladder must include every permitted endpoint-local hidden register and relevant local provenance.

A.38 Observer Assembly

An observer assembly is a generated persistent structure capable of receiving local inputs, preserving records, comparing histories, and producing further actions or predictions.

An observer does not receive privileged access to the complete genesis ledger.

A.39 Operational Identity

A history possesses operational identity when a defining signature persists through change, transport, repair, or reconstruction.

Operational identity does not require the same primitive cubes to remain in the same locations.

A.40 Operational Signature

An operational signature is the complete recorded response of a cube, history, or assembly to a specified standardized probe family.

Signatures may be refined whenever new probes become available.

A.41 Passive Probe

A passive probe is a persistent pattern whose interaction does not substantially reorganize the source-conditioned region being measured.

Passivity is approximate and must be tested through comparison with worlds in which the probe is absent.

A.42 Persistent Assembly

A persistent assembly is one whose generative organization remains recognizable across a defined class of updates and disturbances.

Persistence may be static, cyclic, translational, reconstructive, genealogical, or statistical.

A.43 Probe

A probe is a reproducible cube or assembly history introduced to test a target context.

A probe may test propagation, clock behavior, orientation response, accessibility, latent structure, exterior signature, or relational correlation.

A.44 Propagation Front

A propagation front is the evolving boundary between contexts already altered by an event and contexts not yet altered under the bounded update rules.

Finite movement of this front supplies the operational ancestry of a limiting signal speed.

A.45 Provenance

Provenance is the complete replayable construction and transformation ancestry of a generated state, history, rule, or assembly.

No recognized alias may replace missing provenance.

A.46 Reachability

Context B is reachable from context A when at least one admissible history beginning at A produces a transferable operational signature at B.

Reachability may be manifest, latent, wrapped, or relational. These forms must be recorded separately.

A.47 Recognition Alias

A recognition alias is a familiar mathematical or physical name attached retrospectively to a generated anonymous structure after explicit operational translation.

The alias never replaces the genesis identifier.

A.48 Recognition Ledger

The recognition ledger stores translations between anonymous generated structures and familiar descriptions.

It may contain aliases such as particle-like history, field-like condition, curvature-like deformation, black-hole candidate, EPR-like pair, or bridge-like interior.

Recognition cannot justify an earlier genesis step. The source papers make this quarantine central to the entire ontogenetic method.

A.49 Relational Latency

Relational latency is a latent structure belonging to a relation among two or more histories rather than to any one endpoint independently.

It may survive separation and constrain later joint outcomes while remaining unreadable through either local manifest state alone.

A.50 Source Candidate

A source candidate is a persistent assembly that generates a reproducible surrounding deformation extending beyond direct contact.

The term does not yet imply mass, charge, or energy.

A.51 Source-Conditioned Region

A source-conditioned region is the collection of contexts whose admissible continuations differ reproducibly from their corresponding reference-world continuations because of the source candidate's presence or history.

A.52 Terminal State

A terminal state possesses no permitted continuation under the active local rules and recorded context.

A terminal state must be distinguished from a latent continuation, an unresolved branch, and a simulation stopped for computational reasons.

A.53 Trapped Set

A trapped set is a causally closed family of states possessing no admissible manifest continuation into the designated exterior domain.

A trapped set may contain continuing internal histories.

A.54 Transport

Transport is a sequence of local operations that preserves enough of an assembly's operational identity for its earlier and later states to be recognized as one continuing history.

Transport need not correspond to movement of the same material cubes.

A.55 Transport Residual

A transport residual is the operational difference between the initial and final states of an assembly after it returns to an equivalent manifest context through a closed transport history.

A stable source-dependent residual may later support curvature- or holonomy-like recognition.

A.56 Vacancy Record

A vacancy record stores the address, former occupancy where applicable, creation event, neighboring contexts, permitted refilling conditions, latent residue, and subsequent movement of a missing-cube condition.

The vacancy is a positive ledger object even though no manifest cube occupies the address.

A.57 Wrapped Assembly

A wrapped assembly is a finite internal construction promoted into one higher-order cube with a specified external interface and preserved concealed provenance.

Wrapping supplies the primary route from relational constraint to internally structured bridge-like object.

A.58 Wrapper Depth

Wrapper depth is the number or structure of nested wrapping operations contributing to an assembly.

Wrapper depth is not automatically physical distance, complexity, mass, or interior volume. Those interpretations require independent operational translation.

Appendix B. Recognition Dictionary

B.1 Object-Like Recognition

A persistent localized history may be recognized as object-like when it preserves an operational boundary or signature, survives transport, responds coherently to encounters, and remains traceable through change.

The mature alias “object” does not imply that one permanent group of primitive cubes constitutes the entity.

B.2 Particle-Like Recognition

An object-like history becomes particle-like when it remains localized, propagates, carries stable transferable signatures, undergoes reproducible encounters, and can be created or removed only through permitted invariant-respecting transformations.

A moving vacancy may qualify even though it is structured absence rather than manifest material.

B.3 Field-Like Recognition

A distributed regional condition becomes field-like when local transitions differ reproducibly throughout a region even where no localized manifest source occupies the tested address.

The field-like condition is first a map of altered possibility, not a numerical value imposed on space.

B.4 Inertial-Like Recognition

A persistent history becomes inertial-like when it resists changes in its established propagation organization and when this resistance is stable across standardized disturbances.

B.5 Mass-Energy-Like Recognition

A source signature becomes mass-energy-like only when it jointly predicts inertial resistance, gravitational deformation, transfer, conservation-like balance, accretion response, and emission response.

Raw cube number, wrapping depth, recurrence rate, or historical load alone does not earn this alias.

B.6 Spacetime-Like Recognition

A domain becomes spacetime-like when generated observers can reconstruct stable relations among events using signal propagation, internal clocks, transport histories, causal accessibility, and observer translations.

A regular implementation array is insufficient.

B.7 Gravity-Like Recognition

A source-conditioned deformation becomes gravity-like when diverse passive probes and clocks reconstruct one common regional continuation structure and when the source itself is generated from the same local rules.

B.8 Curvature-Like Recognition

A regional structure becomes curvature-like when path convergence, clock comparison, closed-transport residuals, and continuation noncommutation can be compressed into one probe-independent description.

B.9 Geodesic-Like Recognition

A free probe history becomes geodesic-like when it follows the common source-conditioned continuation structure without an object-specific directional rule or direct source contact.

B.10 Horizon-Like Recognition

A dynamically generated boundary becomes horizon-like when it separates exteriorly reachable contexts from a structurally certified trapped set and when the boundary responds consistently to source changes, accretion, and emission.

B.11 Black-Hole-Like Recognition

A structure becomes black-hole-like when it combines:

persistent sourcehood;

exterior gravitational deformation;

a dynamically generated closed horizon;

continuing concealed internal history;

invariant-constrained accretion and emission;

a stable exterior operational signature.

A cavity, absorber, terminal deletion zone, or one-way wall is insufficient.

B.12 EPR-Like Recognition

A separated pair becomes EPR-like when its joint outcomes require a persistent relational record, vary contextually with endpoint probes, resist decomposition into independent endpoint response assignments, and satisfy local no-signaling-like tests.

B.13 Bridge-Like Recognition

A concealed relational assembly becomes bridge-like when it exposes separated interfaces and possesses its own ordered internal continuation, paths, cycles, clocks, defects, and transport relations.

Correlation alone does not earn spatial or geometric language.

B.14 EPR-Bridge Recognition

An anonymous structure earns the combined EPR-bridge alias when one relational history supports both:

an EPR-like endpoint description;

a concealed interior bridge-like description.

The two translations must preserve the same operational tests and must not add unsupported traversability.

B.15 ER–EPR-Like Recognition

An ER–EPR-like recognition becomes appropriate when both endpoint interfaces are horizon-like, the relational object remains nonfactorizable and no-signaling-like, and the bridge and EPR descriptions achieve at least bidirectional structural translation.

Replay equivalence would support the strongest form of the recognition.

B.16 Singularity-Like Recognition

A region becomes singularity-like only relative to a previously successful effective geometry that cannot be extended through it.

The primitive cube history may terminate, continue recursively, branch without compressible limit, or remain regular under a nongeometric description.

B.17 Entropy-Like Recognition

A multiplicity becomes entropy-like when many reachable fine histories correspond to one coarse operational state and when that multiplicity predicts transitions, equilibrium-like behavior, or information accessibility.

Formal configuration count alone is insufficient.

B.18 Temperature-Like Recognition

An ordering becomes temperature-like when emitted histories produce reproducible detector equilibria and stable exchange directions among source assemblies.

Emission alone is insufficient.

B.19 Holographic-Like Recognition

A boundary–interior relation becomes holographic-like when the complete physically consequential interior can be reconstructed from a lower-order boundary history or from paired boundary histories through a verified translation.

Correlation or coarse prediction alone is weaker than reconstruction.

B.20 Quantum-Gravity-Like Recognition

A regime becomes quantum-gravity-like when geometry, causal accessibility, branching, relational latency, and observer records can no longer be separated into one classical continuation structure, yet remain jointly generated and verifiable through the primitive cube ledger.

The term should not be attached merely because the model is discrete or because it contains both quantum and gravitational vocabulary.

Appendix C. Minimal Computational Protocol

C.1 Purpose

The first computational experiment should test only the earliest nontrivial claim of the paper:

Can a persistent cube assembly modify the admissible histories of surrounding probes through bounded local rules, without any rule referring to attraction, distance from a source, curvature, mass, or gravity?

The experiment should not initially seek black holes or EPR bridges. Those structures depend on earlier achievements and should be investigated only after source-conditioned continuation deformation has been independently certified.

The minimal progression is:

persistent assembly
→ surrounding transition modification
→ finite outward propagation of that modification
→ common response among distinct probes
→ clock and transport effects
→ gravity-like recognition

Failure at an early stage should halt recognition at that level while preserving the generated world for other forms of analysis.

C.2 Minimal World State

A world state should contain a finite address region with explicit boundary handling. Periodic boundaries, reflecting boundaries, expandable boundaries, and open-loss boundaries should be tested separately because each may create artifacts.

Every address stores:

a manifest cube, a latent record, or a missing condition;

the orientation of any manifest cube;

the active panel, seam, and junction marks;

direct contact relations;

a bounded local history;

the provenance of its current state;

its membership in any wrapped assembly;

all unresolved branches associated with that context.

The implementation may use a regular address array for convenience, but no recognition procedure may treat visual array coordinates as physical distance without an operational reconstruction.

C.3 Reduced Cube Alphabet

The complete labeled-cube population is too large for the first experiment. A reduced alphabet should therefore be used while preserving the distinction among panel, seam, and junction sites.

One minimal design may provide:

two panel marks;

two seam marks;

two junction marks;

three occupancy modes;

a small orientation family;

one optional latent interface register.

The exact mark count is not physically meaningful. It is a search parameter.

Several alphabet sizes should eventually be tested to determine whether a discovered phenomenon is robust or depends on one specially tuned encoding.

A reduced cube remains provenance-complete. Compression of the active alphabet must not collapse the distinction between site classes, orientation, presence, latency, and absence.

C.4 Local Context Window

The first update family should inspect only a bounded context containing:

the focal cube;

its directly contacted neighbors;

the occupancy mode of each neighboring address;

the marks exposed at each contact;

the focal cube’s current orientation;

one or more recent local states;

any latent record attached to the active contact.

The permitted context depth should be declared before running the search.

A rule using a three-stage local history is different from a rule using only the current state. The history depth forms part of the primitive law and must be included in the rule identifier.

No update may query:

the total number of cubes in the world;

distance to a designated source;

the global density distribution;

a precomputed shortest path;

the membership of an address in a horizon;

the expected output of a gravitational model;

the complete state of a distant region.

Any such access would invalidate the strongest ontogenetic claim.

C.5 Primitive Update Actions

Each rule may select from a small neutral action library:

retain the current state;

replace one or more exposed marks;

exchange marks across a contact;

reorient a manifest cube;

create a contact;

remove a contact;

convert a manifest cube into latency;

convert latency into manifestation;

create a missing condition;

fill a missing address;

move a vacancy through local replacement;

attach a local history record;

promote a recurrent history;

wrap a certified persistent assembly;

detach a wrapped subassembly.

Every action must produce a complete replay record.

Rules should be generated from syntactic templates containing these actions rather than written individually after examining desired outcomes.

C.6 Update Scheduling

Several scheduling regimes should be compared:

synchronous updating;

asynchronous updating under a reproducible fixed order;

randomized local updating with recorded seeds;

event-triggered updating;

partially ordered regional updating;

different update rates at different wrapping levels.

A candidate phenomenon is stronger when it survives several scheduling regimes or when the generated observer cannot detect the underlying scheduler through local experiments.

If gravity-like behavior disappears whenever the arbitrary update order changes, it may be an artifact of scheduling rather than a robust property of the rule.

The global scheduler belongs to the implementation layer. Internal clocks must emerge from recurrent cube histories rather than inherit the scheduler directly. The temporal source paper explicitly distinguishes update order from physical time and requires internal clocks and observer comparison before a time-like interpretation is justified.

C.7 Vacuum Discovery

The program should begin by generating candidate recurrent backgrounds.

A background qualifies for deeper study when it supports:

bounded propagation;

long-lived local regularity;

several stable probe families;

recurrent clock-like assemblies;

recovery from small disturbances;

no rapidly dominant global synchronization;

no immediate collapse into total vacancy or total uniformity.

The vacuum should be generated, not manually drawn.

Several candidate vacua may emerge from one rule under different initial conditions. Each should receive a separate identifier because source behavior may depend on the background phase.

The vacuum record should contain:

its construction history;

its recurrence or statistical-stability certificate;

its preferred microscopic directions, if any;

its propagation atlas;

its clock atlas;

its latent activity;

its vacancy activity;

its response to standardized perturbations.

C.8 Persistent-Assembly Search

Local disturbances are introduced into the candidate vacuum. These disturbances may be manifest substitutions, latent insertions, vacancy pairs, orientation defects, or small wrapped assemblies.

The system then searches for histories exhibiting:

static persistence;

cyclic persistence;

translational persistence;

reconstructive persistence;

genealogical persistence;

stable statistical recurrence.

A persistent candidate must survive without external intervention after its initial construction.

The persistence detector should measure:

history depth;

boundary stability;

repair capacity;

propagation behavior;

dependence on surrounding vacuum;

internal latent cycles;

vacancy circulation;

response to orientation and translation.

A persistent assembly is promoted as a source candidate only after passing neutral persistence tests. No gravitational behavior should be used in this promotion stage.

C.9 Reference Probe Library

The probe library should contain several independently constructed persistent patterns.

Probe diversity is essential because one specialized pattern may interact with a source through ordinary label matching rather than through a common geometry-like deformation.

Candidate probes should vary in:

site-mark composition;

orientation;

internal cycle length;

wrapping depth;

vacancy content;

latent content;

boundary shape;

propagation mechanism.

Every probe should first be tested in the reference vacuum.

The atlas records:

its stable propagation histories;

its average and minimum continuation depths;

its internal clock accumulation;

its sensitivity to microscopic orientation;

its response to small environmental defects;

its closed-transport signature;

its tendency to disturb the background.

Only sufficiently passive probes should be used for initial gravitational recognition.

C.10 Paired-World Comparison

For every source candidate, create two matched worlds.

The reference world contains the vacuum and probe protocol but no source.

The source world contains the same vacuum, initial conditions, and probe protocol plus the persistent source assembly.

The two worlds should use identical scheduling, boundary conditions, and random seeds where applicable.

The ledger compares:

the first stage at which the probe histories diverge;

the addresses at which divergence occurs;

the branch families added or removed;

the additional latent stages;

the changes in internal clock cycles;

the changes in vacancy motion;

the changes in closed-transport residuals;

the final operational signatures.

The difference between the paired worlds is the primitive deformation record.

No claim of gravity follows from the existence of a difference alone.

C.11 Excluding Direct Contact

The first geometry-like tests should use probe histories that never contact the source assembly.

The program must verify that every source–probe influence passes through a chain of locally modified intervening contexts.

The earliest divergence should occur near the source and propagate outward no faster than the independently measured propagation limit.

If a distant probe changes before the intervening region changes, one of three conditions holds:

the rule is nonlocal;

a latent connection already joins the regions;

the bookkeeping or comparison procedure is incorrect.

Each possibility must be recorded explicitly.

A source-conditioned field-like region is credible only when its formation can be replayed as a sequence of bounded local modifications.

C.12 Multi-Probe Universality Test

Release several probe families through the same source-conditioned region.

Their microscopic cube histories will generally differ. The question is whether their coarse operational deformation can be predicted by one common regional structure.

The comparison should include:

directional change;

continuation depth;

relative arrival ordering;

clock accumulation;

neighboring-path convergence;

closed-loop residual;

escape accessibility.

A universal deformation candidate exists when one compressed regional model predicts these features for several independent probes better than separate object-specific interaction models.

The model must be tested on probes not used during its construction.

Universality inferred only from the training probes is insufficient.

C.13 Clock Test

Construct two equivalent recurrent clock assemblies.

Place one in the reference region and one in the source-conditioned region. Alternatively, transport one clock along a source-proximal history and another along a distant history before reuniting them.

The comparison records:

completed internal cycles;

partial-cycle state;

latent stages accumulated;

repair operations required;

interface changes;

damage or direct-contact events.

A gravitational-clock candidate exists when:

the clocks remain operationally intact;

the cycle difference is source-correlated;

the effect occurs across several clock designs;

the result cannot be attributed to direct contact or scheduler priority;

the same regional model predicting probe deformation predicts the clock difference.

The genesis ledger records divergent histories. “Time dilation” appears only as a later recognition alias.

C.14 Closed-Transport Test

A stable assembly is transported through a sequence of locally defined steps returning it to an equivalent manifest context.

The procedure is performed in the reference vacuum and in the source-conditioned region.

The final state is compared with the initial state under a probe family including:

orientation;

internal phase;

latent register;

vacancy relation;

boundary signature;

clock state.

A source-dependent transport residual provides evidence stronger than visual path bending.

Alternative loops should be tested.

A curvature-like candidate becomes increasingly credible when the residual depends systematically on the enclosed source organization and not merely on the number of transport steps.

C.15 Source Scaling Experiment

Generate related sources differing by one controlled construction feature at a time.

Vary:

constituent count;

persistence depth;

repair frequency;

internal cycle length;

latent mediation depth;

vacancy organization;

wrapping depth;

boundary complexity.

For each source, measure the surrounding deformation atlas.

The analysis asks which source features predict:

deformation range;

probe delay;

clock divergence;

transport residual;

branch funneling;

trapping threshold.

The best source signature is the smallest provenance-grounded record predicting the largest family of exterior effects.

A mass-energy-like alias remains prohibited until the same signature also participates in inertial response, transfer, and conservation-like relations.

C.16 Trapping Search

Only after stable source deformation has been established should source strength or organization be increased in search of trapping.

The program monitors:

the number of outward continuation families;

minimum escape depth;

maximum tested escape depth;

stability of escaping branches;

probe-family dependence;

boundary fluctuations.

A region in which most probes fail to escape is not yet a horizon.

The search must retain every branch and distinguish:

temporary capture;

species-specific capture;

damaged probes;

terminal deletion;

material enclosure;

unresolved deep escape;

structurally certified trapping.

The horizon search begins only when a closed continuation class can plausibly be constructed.

C.17 Relational-Pair Search

In parallel with the gravitational search, local encounters should be screened for relational persistence.

A pair candidate begins when a local parent history generates two separable descendants and a shared latent record.

After separation, the system tests whether:

the descendants retain stable individual identities;

the shared relation remains operationally active;

different probe contexts generate reproducible joint constraints;

the relation survives ordinary local perturbation;

one endpoint alone cannot reconstruct the full joint behavior.

Pairs passing these tests enter the factorization analysis described in Appendix A and the main text.

Ordinary common-cause correlations should remain in the ledger as lower-level discoveries.

C.18 Paired-Horizon Experiment

Once both horizon and relational-pair candidates exist, combine them without modifying the primitive rules.

Each endpoint is permitted to accumulate source-like organization and develop a trapping boundary.

The experiment asks:

Does the relational record survive horizon formation?

Does it become attached to the horizon interfaces?

Does either exterior observer retain local access to the relation?

Can the pair still pass no-signaling-like tests?

Does the minimum relational representation develop internal structure?

Can the two concealed interiors be represented as one wrapped assembly?

Only after these questions are answered should an EPR-bridge recognition be attempted.

Appendix D. Certification and Falsification Checklist

D.1 General Provenance Certification

Every candidate must provide:

a primitive-rule identifier;

a complete initial state;

the update scheduler;

all random seeds;

all branch records;

all latent-state transitions;

all vacancy histories;

all wrapping and unwrapping records;

the complete probe protocol;

the recognition criteria fixed before evaluation;

an independently replayable final state.

Any missing item reduces the result to unresolved status.

D.2 Locality Certification

The verifier must establish that every primitive update reads only the declared bounded context.

Indirect global access must also be excluded.

A cached field calculated from the entire world remains global even when a local rule reads only its nearby cached value.

A source-distance table remains imported geometry even when consulted one address at a time.

A horizon-membership flag remains inserted black-hole structure even if locally stored.

Locality must be established from the complete dependency graph of the implementation.

D.3 Gravity-Candidate Checklist

A gravity-like claim requires affirmative evidence that:

the source is a generated persistent assembly;

the surrounding deformation extends beyond direct contact;

the modification propagates at finite speed;

several passive probe families respond coherently;

internal clocks reconstruct a compatible effect;

closed transport produces a source-dependent residual or an explicit reason is given for its absence;

the result survives reversible readdressing of the world;

the result is not caused by scheduler workload;

the primitive rule contains no source-directed instruction;

the effective description predicts withheld probe histories.

Failure of one item does not erase the observed phenomenon, but it lowers the permitted recognition level.

D.4 Black-Hole-Candidate Checklist

A black-hole-like claim additionally requires:

a persistent source-conditioned exterior deformation;

a closed candidate trapping region;

branch-complete escape analysis;

a structural closure certificate or an explicit unresolved designation;

a dynamically generated boundary;

multiple trapped probe families;

continuing interior histories or a clearly classified terminal interior;

a stable exterior signature;

accretion behavior constrained by generated invariants;

horizon response to source change;

exclusion of fixed walls, deletion zones, and ordinary cavities.

A dark rendered region is not evidence.

A probe that disappears is not sufficient.

A very long escape time is not a proof of nonescape.

D.5 EPR-Like Checklist

An EPR-like claim requires:

a local common-origin history;

two later manifestly separated endpoints;

several probe choices at both endpoints;

a complete joint-outcome ledger;

endpoint-local hidden states included in factorization attempts;

failure of every permitted independent endpoint decomposition under the tested context;

stable relational prediction of joint outcomes;

no-signaling-like local branch families;

no hidden global coordinator;

persistence under declared disturbance classes.

A matched pair, common random seed, or shared lookup table is insufficient.

D.6 Bridge-Like Checklist

A bridge-like claim requires:

two exposed interfaces;

one concealed provenance-complete assembly;

internal ordered continuation;

more structure than a direct endpoint lookup;

reproducible internal transformation histories;

a distance-, depth-, or path-like operational measure;

a declared traversability status;

causal-cycle analysis for any transport capability;

an explicit translation between relational and interior descriptions.

A drawn tunnel, vacancy corridor, or instantaneous endpoint copy is insufficient.

D.7 ER–EPR-Like Checklist

The strongest combined recognition requires:

EPR-like nonfactorization;

local no-signaling;

paired horizon interfaces;

one common concealed relational assembly;

bridge-internal structure;

bidirectional translation between endpoint-correlation and bridge-interior descriptions;

no unsupported transport predicted by the geometric alias;

no joint correlation omitted by the bridge alias;

complete common provenance.

Replay equivalence should be distinguished from partial structural correspondence.

D.8 Artifact Tests

Every candidate should be tested against common implementation artifacts:

boundary reflections;

periodic-world shortcuts;

update-order bias;

memory aliasing;

uninitialized hidden registers;

random-seed reuse;

improper branch pruning;

floating-point nondeterminism;

probe-induced source modification;

incorrect equivalence merging;

rendering-dependent measurement;

global analysis leaking into generation.

A phenomenon disappearing after correction should be retained as a negative record rather than omitted.

D.9 Counterfactual Source Removal

Remove the source while preserving as much of the surrounding state as possible.

Several outcomes are informative.

If the deformation immediately disappears everywhere, the implementation may contain global source dependence.

If it decays outward through finite stages, the region behaves like a locally maintained field.

If it persists indefinitely, the background has acquired its own memory.

If it reorganizes into a propagating disturbance, the source had stored deformation in the surrounding medium.

The result helps distinguish active source dependence from historical field residue.

D.10 Counterfactual Provenance Exchange

Construct two manifestly identical sources with different histories.

If their surrounding deformations differ, provenance remains gravitationally active.

Construct two visibly different sources with matching candidate source signatures.

If their exterior deformations agree, a useful source compression has emerged.

These paired tests determine whether gravitation depends on present appearance, hidden state, complete history, or a smaller discovered invariant.

D.11 Probe Replacement Test

Replace the original probe family with newly generated passive probes.

A geometry-like interpretation should generalize.

If the deformation changes arbitrarily with probe identity, the phenomenon remains interaction-like.

If different probes agree only after coarse wrapping, the geometry has a scale-dependent domain of validity.

This result should be stated rather than concealed.

D.12 Coordinate Re-Encoding Test

Re-encode the same world under a different reversible address convention.

Replay all events.

The recognition-level claims must remain invariant.

If a horizon, source strength, distance, or bridge exists only under one visual embedding, it has not been operationally generated.

D.13 Scheduler Substitution Test

Replay the candidate world under every compatible scheduling regime.

Exact histories may differ. The question is whether the higher-level phenomenon survives.

A robust gravity-like regime should preserve source-conditioned universality even when microscopic timing changes.

A robust horizon should preserve causal trapping.

A robust EPR-like relation should preserve nonfactorizable joint structure.

Dependence on one scheduler is not automatically disqualifying, but the scheduler must then be treated as part of the primitive physics rather than as neutral implementation detail.

D.14 Scale Test

Repeat the recognition at several wrapping levels and probe resolutions.

A candidate may strengthen under coarse observation, weaken under fine observation, or divide into several distinct regimes.

The report must specify:

the smallest scale at which the recognition succeeds;

the largest scale tested;

the residual microscopic violations;

the rate at which coarse descriptions converge;

whether the horizon or bridge changes with probe scale.

Smoothness and universality are scale-dependent achievements.

D.15 Negative-Result Certification

A negative result should be certified with the same care as a positive result.

The record should state:

the rule family searched;

the number of worlds generated;

the selection criteria;

the persistence thresholds;

the probe families;

the maximum continuation depth;

the factorization search limits;

the horizon-certification method;

the computational resources;

the unresolved cases.

Failure to find a phenomenon is not proof of impossibility unless the searched rule family and state space have been exhaustively covered.

The correct conclusion may be:

not generated within the tested family and bounds.

D.16 Termination Conditions

A candidate investigation should terminate when:

the primitive provenance becomes incomplete;

the recognition depends on an unverified compression;

the required search exceeds declared bounds;

branch growth prevents certification;

the candidate fails a necessary threshold;

a simpler nonphysical explanation fully accounts for the behavior;

the result has been independently reproduced and no further planned recognition level remains.

Termination is not abandonment. It is fail-closed completion of the current claim.